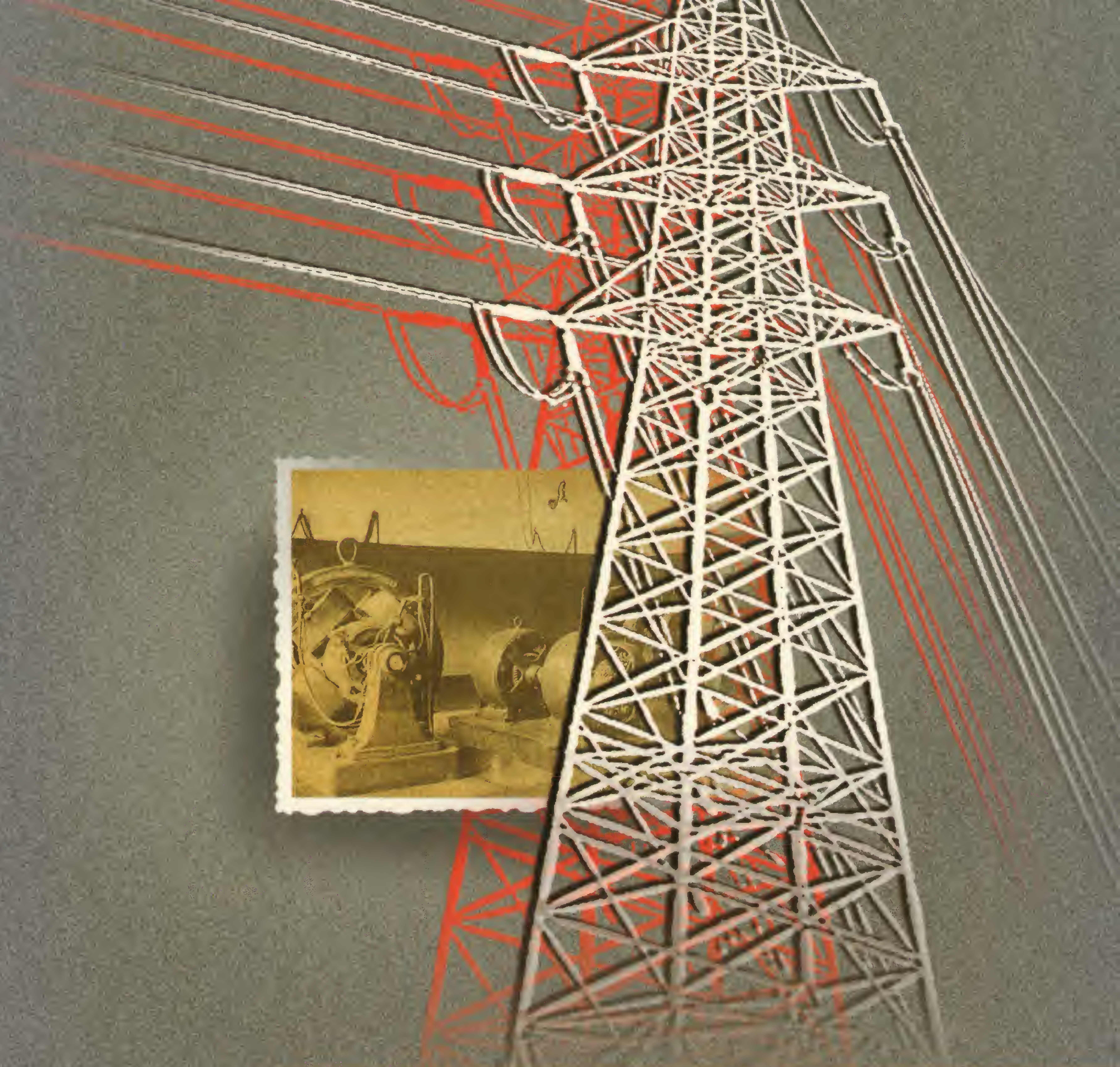

Mire Spirov

History of Electrification in Bulgaria

Electroimpex

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HISTORY OF ELECTRIFICATION IN BULGARIA
Assoc. Prof. Mire Spirov, *M.Sc. Electrical Engineer*

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Written by *Assoc. Prof.* Mire Spirov, *M.Sc. Electrical Engineer*
Science editor Alexander Vaklinov, *M.Sc. Electrical Engineer*
Copy editors Mariana Dotsinska and Zlatka Barakova
Translation by Lyudmila Dimova
Art Direction by Ventseslav Dyankov
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Electroimpex plc
17, G. Washington Street, 1040 Sofia, BULGARIA
Tel: (+359 2) 86 181, Telex: 22959, Fax: (+359 2) 980 0272
E-mail: elimpex@mb.bia-bg.com
http://www.electroimpex.com

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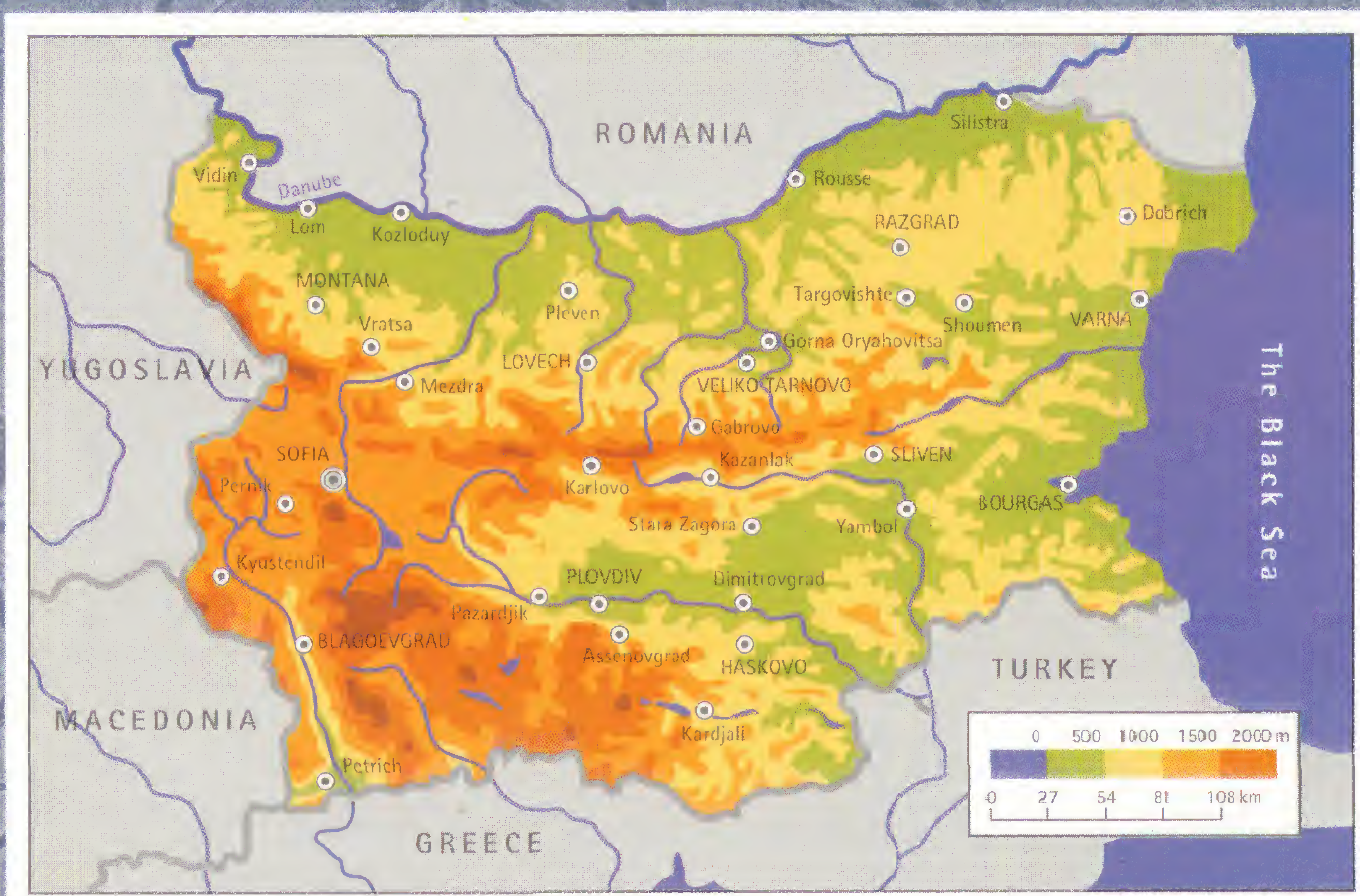
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FOREWORD

Electrification is an essential part of the modern history of Bulgaria, starting with the first electric bulb lit up in Sofia 120 years ago and the first tram introducing in the capital, followed by many hydro and thermal power plants constructed through the years and reaching the 1000 MW reactors of our first nuclear power plant in Kozloduy. Being the backstone of our economy, the power sector has played a priority role in determining the main economic tendencies in our country.

Regardless all economic shocks and difficulties arising from the accelerated introducing of the market economy, the Bulgarian power sector has not been affected a lot, moreover it has always given a stable support to our economy, even in the most difficult years. This is an inevitable proof of the good professionalism and experience of the founders and creators of our power system.

Electroimpex has also greatly contributed to the Bulgarian power sector, making it popular abroad by the fulfillment of complete turnkey electric power projects and keeping the Bulgarian "know-how" at a high competitive level.

By publishing this book, Electroimpex has the good will and intention to make the history of Bulgarian Electrification more popular among our foreign partners. We have been led by the good maximum: "One who knows History well, will become a master of the Future. One who masters the Present, is a master of History, too". It is worth knowing the companies and the people who have established and developed our electrification – from the very beginning to the construction of the nuclear power plant in Kozloduy, the unique Chaira pumped storage hydro power plant and the 750 kV overhead transmission lines on the territory of Bulgaria, which for many countries is only a dream.

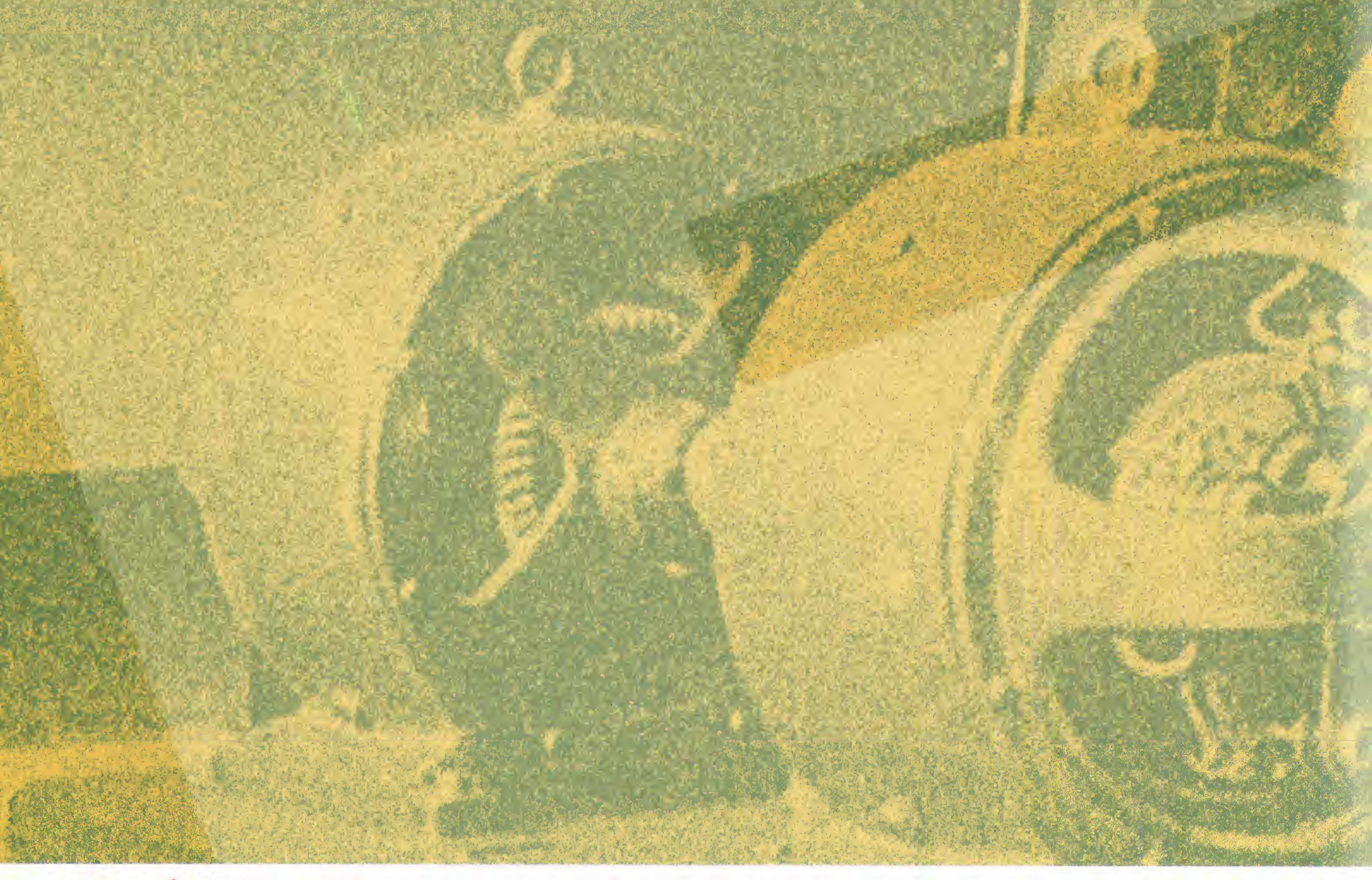
It was not by chance that we chose Assoc. Prof. Mire Spirov, M.Sc. Electrical Engineer, to write this book. He is a famous Bulgarian expert, with a great experience in the studies, design and development of the Bulgarian power sector, and also an established author of a number of historical books about electrification.

We sincerely hope this book will give the readers a more detailed view to the Bulgarian achievements in the field of electrification. It is a confirmation of the already proved trust in the Bulgarian engineering companies and their reputation as reliable partners of world-known foreign companies.

Alexander Vaklinov
Executive Director, Electroimpex

1

Beginning and Local Electrification 1879–1918



Electrification, as an acquisition of material civilization and culture, began in Bulgaria almost simultaneously with that in the developed European countries - during the last two decades of the 19th century, first by using electricity for lighting purposes only and later on as a motive power.

The Royal Palace in Sofia
where the first electric bulb in Bulgaria was lit up (July 1st, 1879)

The fact that Bulgaria, recently liberated from Turkish yoke (in 1878) took brave steps to introduce electric street lighting in its capital city Sofia while Western Europe was still fighting its way through lighting gas, is a significant point in Bulgarian history. The high interest of Bulgarian people in electric lighting could only be explained as a continuation of the ideas of Bulgarian Renaissance.

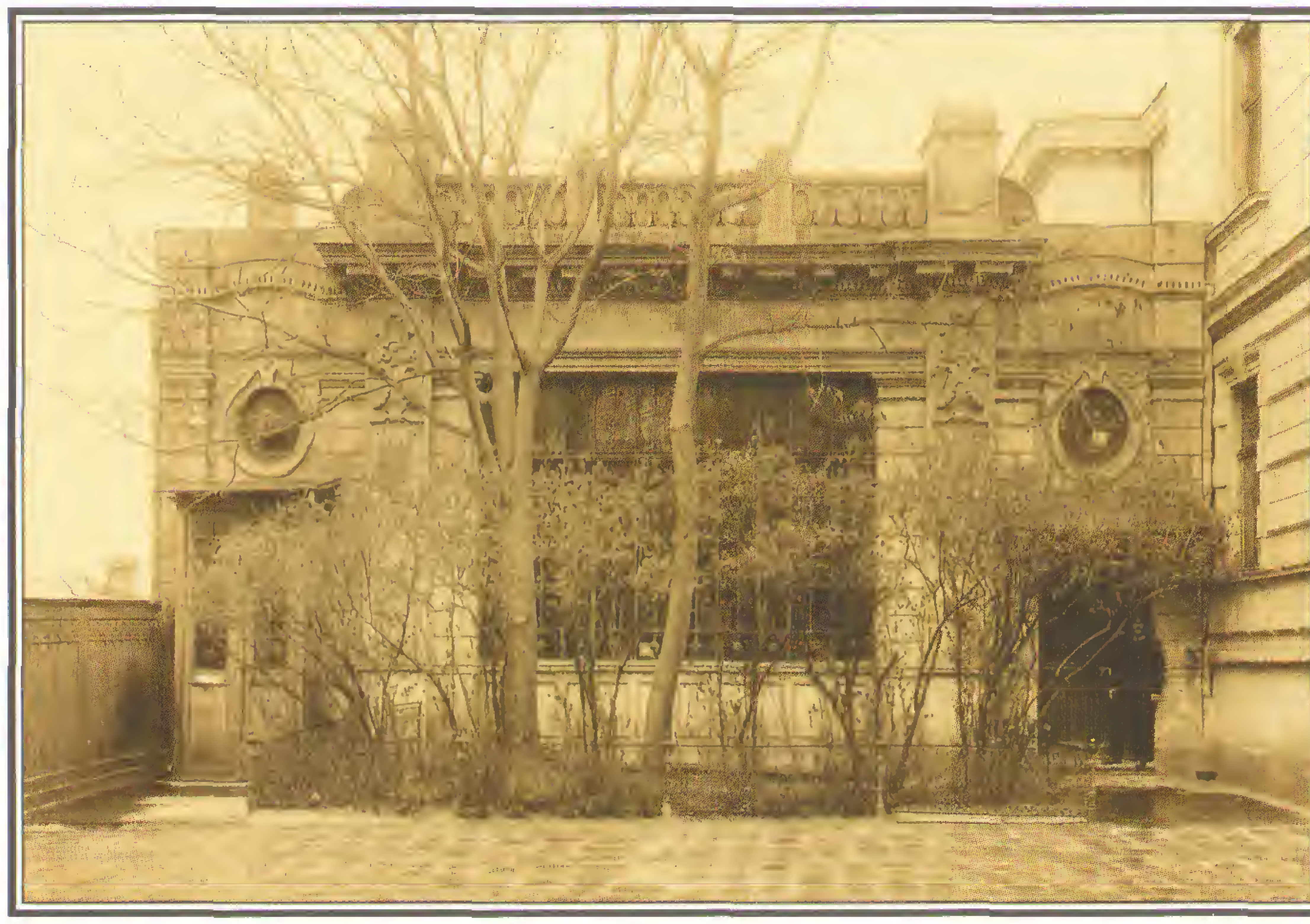
So, on July 1st 1879, during the coronation ceremony of Prince Alexander Batenberg–the first Bulgarian Royal Prince of the Third Bulgarian Kingdom, the Royal Palace was lit up with electric bulbs powered by electrical installation supplied from Vienna. After 1885 electrical lighting was also introduced in some other Bulgarian towns, such as Gabrovo, Kazanlak, etc., as well as at the Plovdiv Fair and at some other individual sites. In 1891 Ivan Hadjiberov's water-mill in Gabrovo was the first to generate electricity from water power by means of primitive facilities.

Table 1 presents the chronological order of the construction of small individual electric power plants and facilities in Bulgaria during the last decade of the 19th century, and the capacity of each one.

Table 1: Individual small power plants and facilities constructed in Bulgaria during the period 1879–1901

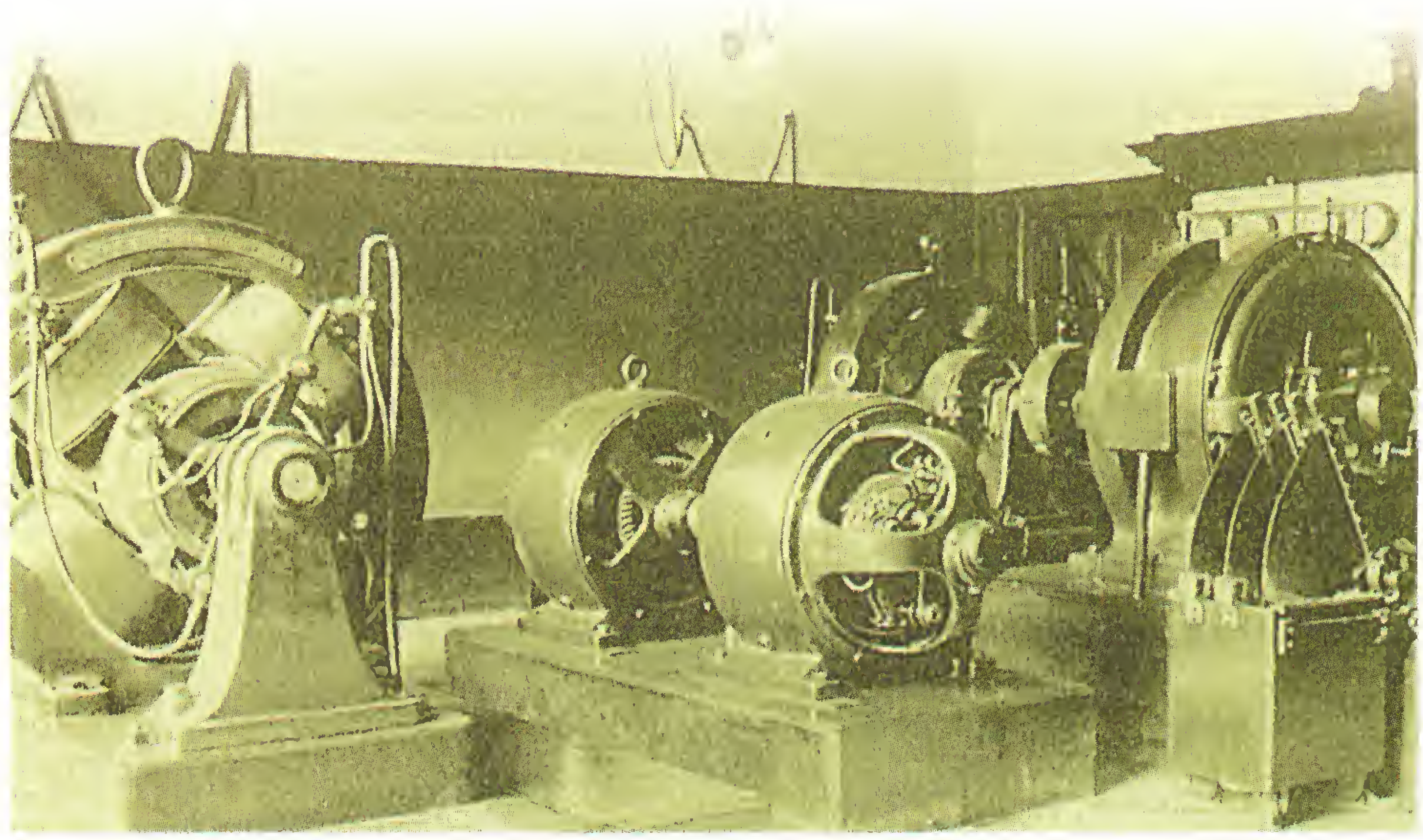
Location	Year of commissioning	Installed Capacity	
		hp*	kW
Royal Palace in Sofia (first electric bulb lit up in Bulgaria)	1879	—	—
"Uspeh" (Ferdinand 1st) Braiding Factory, Gabrovo	1888	—	—
Rose Valley Wool Spinning Mill, Kazanlak	1889	—	—
Hadjiberov's Water-Mill, Gabrovo	1891	—	—
Hadjiberov's and An. Momarin's Wool Weaving Workshop, Gabrovo	1892	—	—
First Plovdiv Fair	1892	—	—
Evksinograd Palace	1893	70	50
Beer Brewery, Shoumen	1893	—	—
Royal Palace in Sofia	1895	220	160
Royal Stables in Sofia	1898	16	12.5
Pernik Coal Mine	1999	45	30
Anti-Plague Institute, Sofia	1900	3	2.5
Parliament	1900	12.5	10
Telegraph and Post Office Administration, Sofia	1901	37.5	30

* The electric motors capacity is stated in **hp** (1 hp=0.735499 kW) for the period until 1948



The Sofia Palace Power Plant
commissioned in 1895
front view

In 1890 Dimitar Petkov, Mayor of Sofia at that time, appointed a special "historical" commission that had to carry out feasibility studies for the electric lighting of the capital city. The commission worked out a program and conditions for the factories wishing to participate in the competition for lighting Sofia with electricity.



Sofia Palace Power Plant
Machine Hall

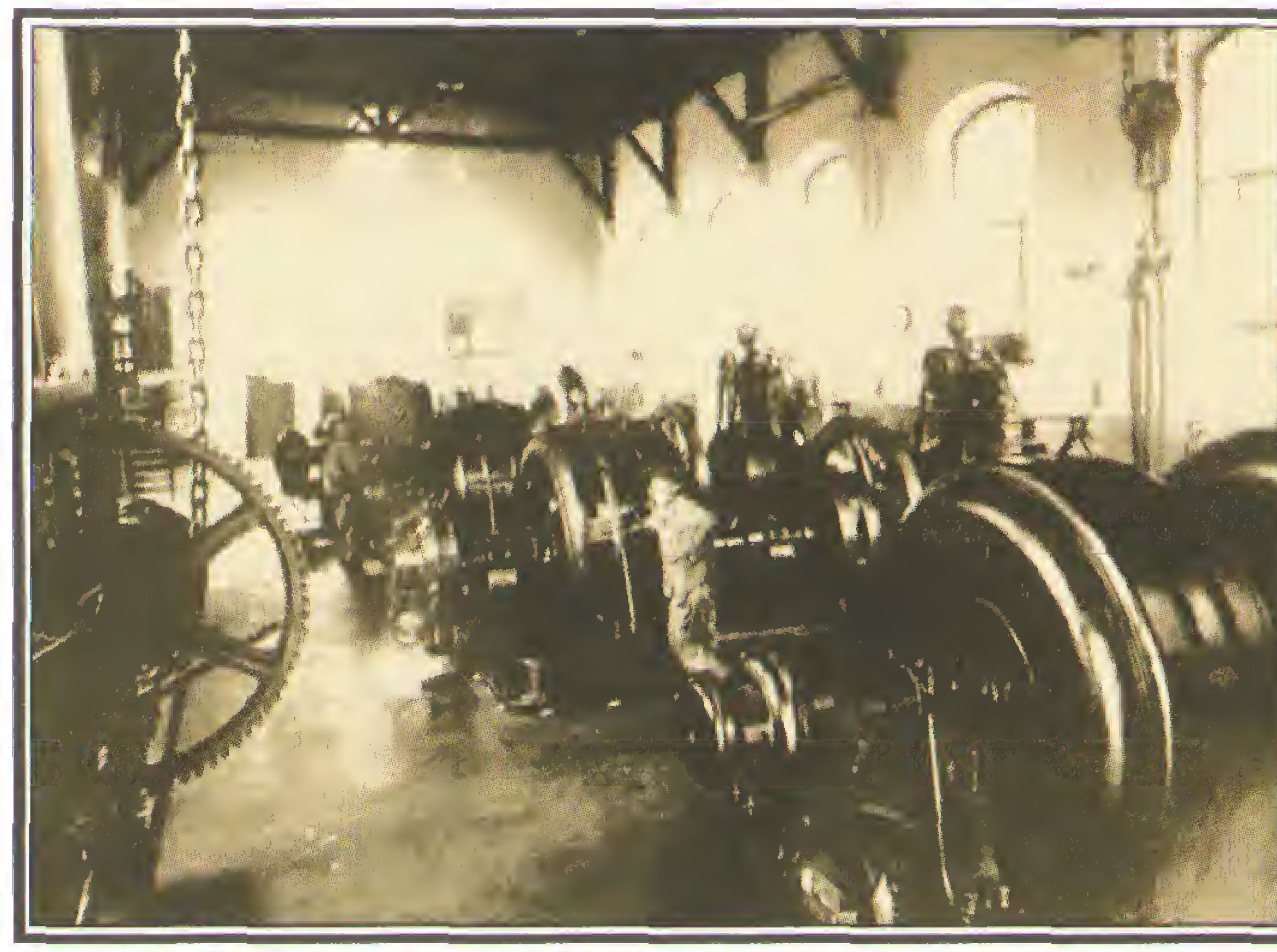
After a number of tenders had been carried out, a decision was made that the Pancharevo Hydro-Power Plant on the Iskar river, 22 km away from Sofia, by the road to Samokov, should be used as the first source of public electricity supply to Sofia. The Belgian company Societe d'Electricite de Sofia et de Bulgarie was a concessionaire of the hydro-power plant, as well as of the transmission and distribution network of the city.

The Iskar river was blocked by means of a stone masonry dam with two steel gates in it, normally in horizontal position, which rose to a vertical position in the event of low water level, thus enabling daily compensation. On the right-hand river bank, there was a draft gate, two vertical shutters and a settling tank chamber, followed by an open concrete culvert 149 m long, and then a 1167 m concrete tunnel of 4.7 m^2 trapezoidal cross-section, with stone lining. The tunnel ended in a water tower and steel pipeline of 110 m length, d=1400 mm.

Pancharevo HPP
commissioned on
November 1st 1900
in operation until 1956
front view

The machine hall of the Pancharevo Hydro-Power Plant was 30 m wide and 12.5 m long, designed to accommodate 6 units. Initially, four units were installed. The turbines were Francis type, made by Picard-Picte & Co., Geneva, with horizontal shaft of 500 hp capacity, 75% efficiency and 400 rpm rotation speed, regulated by a centrifugal governor. They were rated for 52-56 m head and 960-910 l/s water discharge.

The generators were of an open type, connected to the turbines by means of an open coupling. Their characteristics were: 430 kVA capacity each, $\cos\varphi=0.8$, voltage 8 kV, frequency 53 Hz, exciter power–9 kW, 50V, 180 A.



Pancharevo HPP

Machine Hall

The construction of the Pancharevo Hydro-Power Plant, as well as of the 22-km, 7 kV overhead transmission line to Sofia and the city distribution network intended for 7 kV, 3 kV and150 V continued for two years pursuant to the contract provisions. The installation works were performed by the Swiss company Oerlicon.

The Pancharevo Hydro-Power Plant and the electric power network of Sofia were commissioned on November 1st 1900 when the population of the capital city amounted to 68 000. That was the beginning of public electricity supply in Sofia and in Bulgaria.

Soon after electric lighting, the electric tram was introduced in Sofia on January 1st 1901 by another Belgian firm. And in 1902, the concessionaire commissioned "Maria Louisa" back-up thermal power plant, near the railway station, with two 600 hp steam engines, each connected to a 450 kW, 7 kV synchronous generator and each of them supplying one DC generator. Thus, the thermal power plant could back up both the electric lighting and the trams. It operated until the construction of the Kourilo power plant (1927).

At the beginning of the 20th century (1901) the electric lighting utility of Sofia had the following characteristics:

❖	Installed capacity of the plant	2 000 hp
❖	7 kV overhead transmission lines, 2x3x50 mm²	16 025 m
❖	Distribution network 7 and 3 kV	14 000 m
❖	Low-voltage network 150 V	32 000 m
❖	Distribution transformers 7000/150 V	14 pcs
❖	Distribution transformers 3000/150 V	5 pcs
❖	Street lamps (according to the agreement terms, 2200 pcs were envisaged, out of which 10 pcs – 16 A (approximately 500 W), and 2000 pcs – 100 W filament lamps)	1 350 pcs
❖	Customers	249 pcs
	out of them private households	246 pcs
	motive power (palace, trams, a mill)	3 pcs
❖	Generated electric power	2 500 000 kWh
❖	Sold electric power, including:	1 429 000 kWh
	lighting of households	190 629 kWh
	street lighting	651 573 kWh
	motive power	3 066 kWh
	electrical trams	584 090 kWh

Thus the young Bulgarian capital skipped the lighting gas and the horse stage-coaches and equaled the developed European countries in terms of electrification.

During the first five years of the development of electric lighting in Sofia there was five-fold increase in consumers and the total electric power consumption was almost doubled. That on the one hand and the summer and winter problems with the Iskar waters on the other hand made the concessionaire expand the Maria Louisa power plant in 1905 by a third, 600 hp steam engine, and in 1908 – by a fourth, 1000 hp steam engine.

In 1912 the first steam turbine in Bulgaria was installed at the plant. It was a 2200 hp Brown Boveri steam turbine completed with a 1500 kW Oerlicon generator.

In 1912 the electric power generated by the power plants of Sofia reached the following figures:

❖ Pancharevo Hydro-Power Plant	5 721 802 kWh
❖ Maria Louisa Thermal Power Plant	1 252 905 kWh
TOTAL:	6 887 540 kWh

against 5 819 921 kWh demand, i.e. with 1 067 619 kWh auxiliary consumption and transmission, transformation and distribution losses, or 15 % of the power generated. By that time the number of consumers had already increased 20 times compared to 1901.

In 1915 the concessionaire, bearing in mind the rapid increase of power demand, ordered a second, 2200 hp unit from the same firms. However, its delivery was delayed due to the breakout of World War I, so it was installed in 1917.

The electrification of Sofia marked the beginning of local electrification in Bulgaria (01.11.1900). In spite of the complicated and uncertain paths followed by the capital city for 10 years (1890-1900), this was quite a contagious example followed by a number of some other large and busy Bulgarian towns, such as Gabrovo, Lom, Kazanlak, Varna, and Rousse which started studies about their electrification, as well.


Общедоетжпно ржководство

по

ИНДУСТРИАЛНО ЕЛЕКТРИЧЕСТВО

Стъкмено по метода Розенбергъ и Модюи.

Частитѣ на Динамо (гледай стр. 83).

отъ

Юрданъ Илковъ

Инженеръ-електрицистъ въ Министерството на Желѣзницитѣ, Пощитѣ и Телеграфитѣ (въ Главната Дирекция за построяване желѣзници и пристанища).

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One of the first Bulgarian books on electrical engineering, 1914

Hristo Lulev HPP

in Gabrovo

in operation since 1911

front view

Hristo Lulev HPP

Machine Hall

The electrification of Gabrovo was begun by Ivan Hadjiberov–an enterprising factory owner, who was the first in Bulgaria to produce electricity from water power. In 1906 his own power plant on the Yantra river near Gabrovo was commissioned. He had been personally involved in its study, design and construction. This was the second power plant for public electricity supply after the Pancharevo HPP (1900), because besides the electric power supply to the weaving workshop, it provided electricity to street lighting, as well.

The hydro-power plant had three water turbines with installed capacity of 80 hp each. That permitted Ivan Hadjiberov to expand the weaving workshop built by him in 1912 by 80 new mechanical looms. His workshop had already 300 workers and annual production of 180 000 m woolen textile.

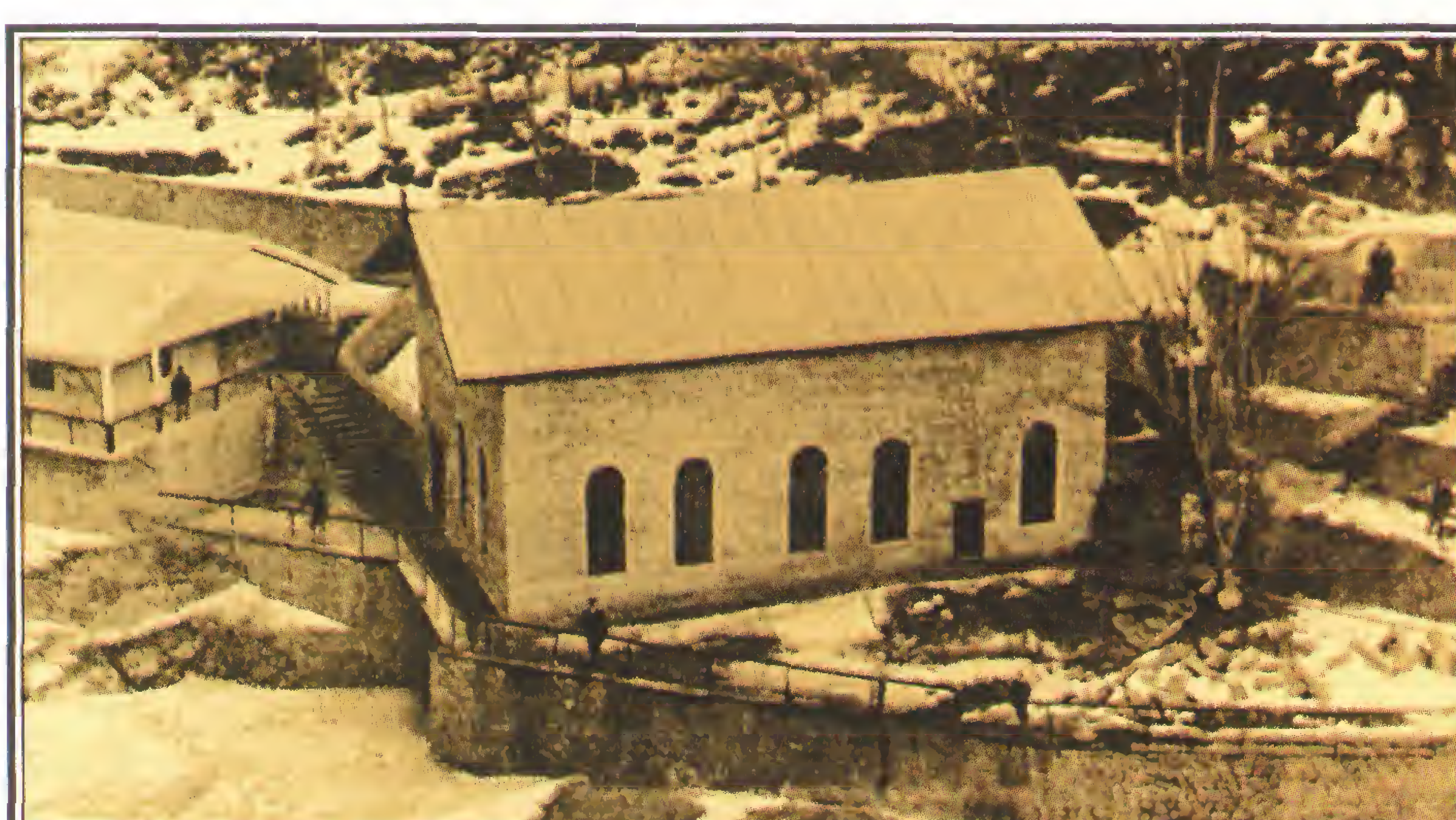
Even nowadays people are still amazed not only by the great industrial interests Ivan Hadjiberov had, but also by his extraordinary intellectual interests as evident from the paintings on the power plant walls, the fascinating diary he kept and the cultural acquisitions he provided for his workers.

The electrification needs of the industrial enterprises in Gabrovo led to the construction of a new private hydro-power plant "Hristo Lulev" on the Yantra river 14 km of Gabrovo. It was commissioned in 1911. The plant had one Francis turbine for 19.5 m water head and 1 m^3/s water flow, with a capacity of 135 kW and a generator for 6400 V three-phase current. The electric power was transmitted to the town at 6 kV. Much later, in 1917, during World War I, part of the electricity generated by Hristo Lulev HPP was allocated for lighting of residential buildings in the town.

So, Gabrovo became the second town in Bulgaria to use electric power in general, but as a town with public power supply it took the fourth place after Sofia, Lom and Kazanlak.

Ivan Hadjiberov HPP

commissioned in 1906
(the second HPP in Bulgaria after Pancharevo HPP)
front view



Lom was a comparatively small town. However, as a port on the Danube, at that time it was the gateway of Bulgaria to Europe. The town electrification assigned by concession to the German firm "Max Storh" started as early as 1907, however, it was implemented as late as 1912. A diesel power plant with two 150 hp generating sets was constructed.

The generating sets were direct-current, for a three-wire system, 100 kW, 440 V, 685 rpm, with belt drive. That was a unique DC system in Bulgaria.

The DC generators were combined with two storage batteries, always charged, which took over the electrical load of the town, between 50 and 100 kW, for 7.5 hours when the power plant did not operate. In this way the town electrical lighting was maintained at nighttime in order to economize on fuel which was rather expensive. Thus Lom, with its population of 15000 people, used storage batteries for a period of 15 years - from 1912 to 1926.

The cooling water heated by the diesel engines was used in the workers' bathroom, and the excess of hot water was given to the town baths.

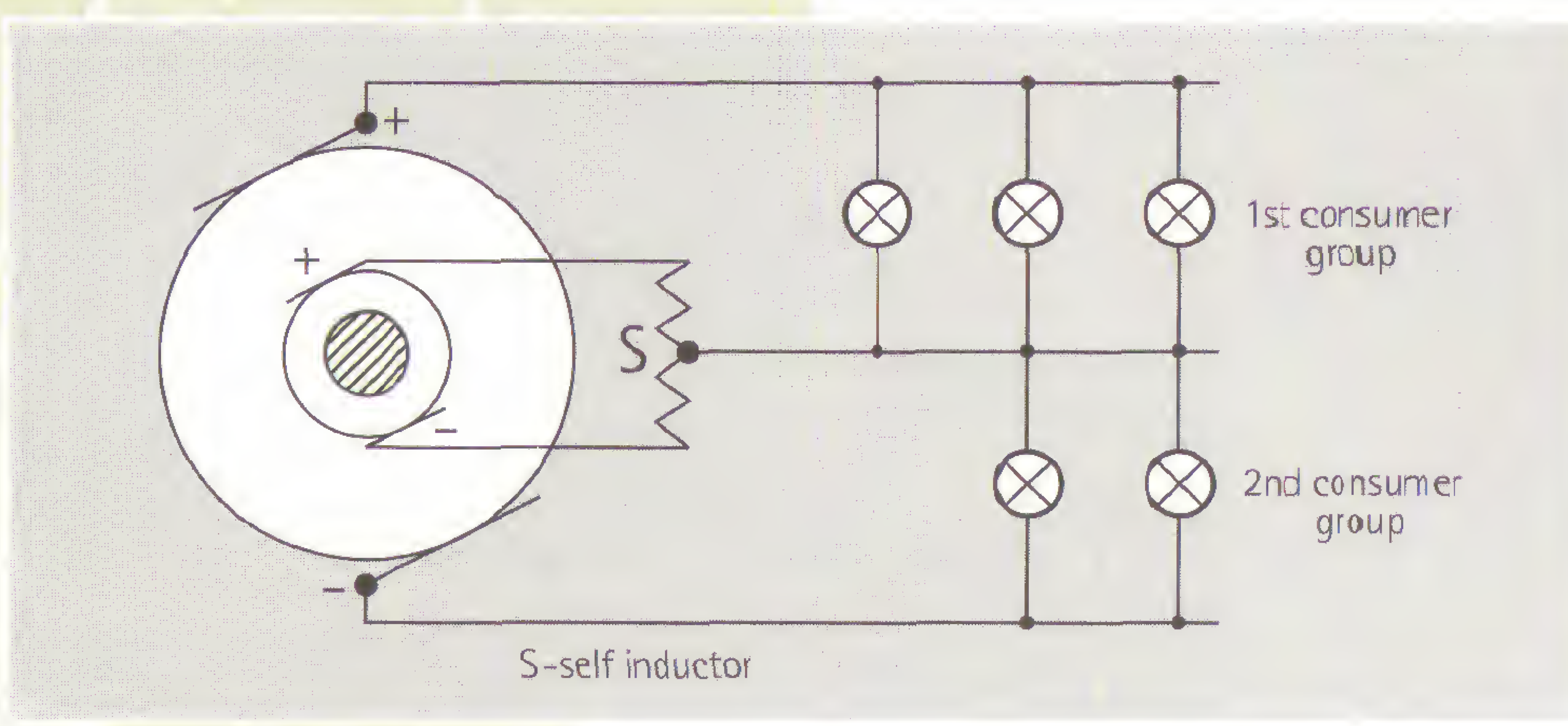


Fig. 1: Lom DPP - diagram of the 440/220 V DC three-wire system introduced in 1912

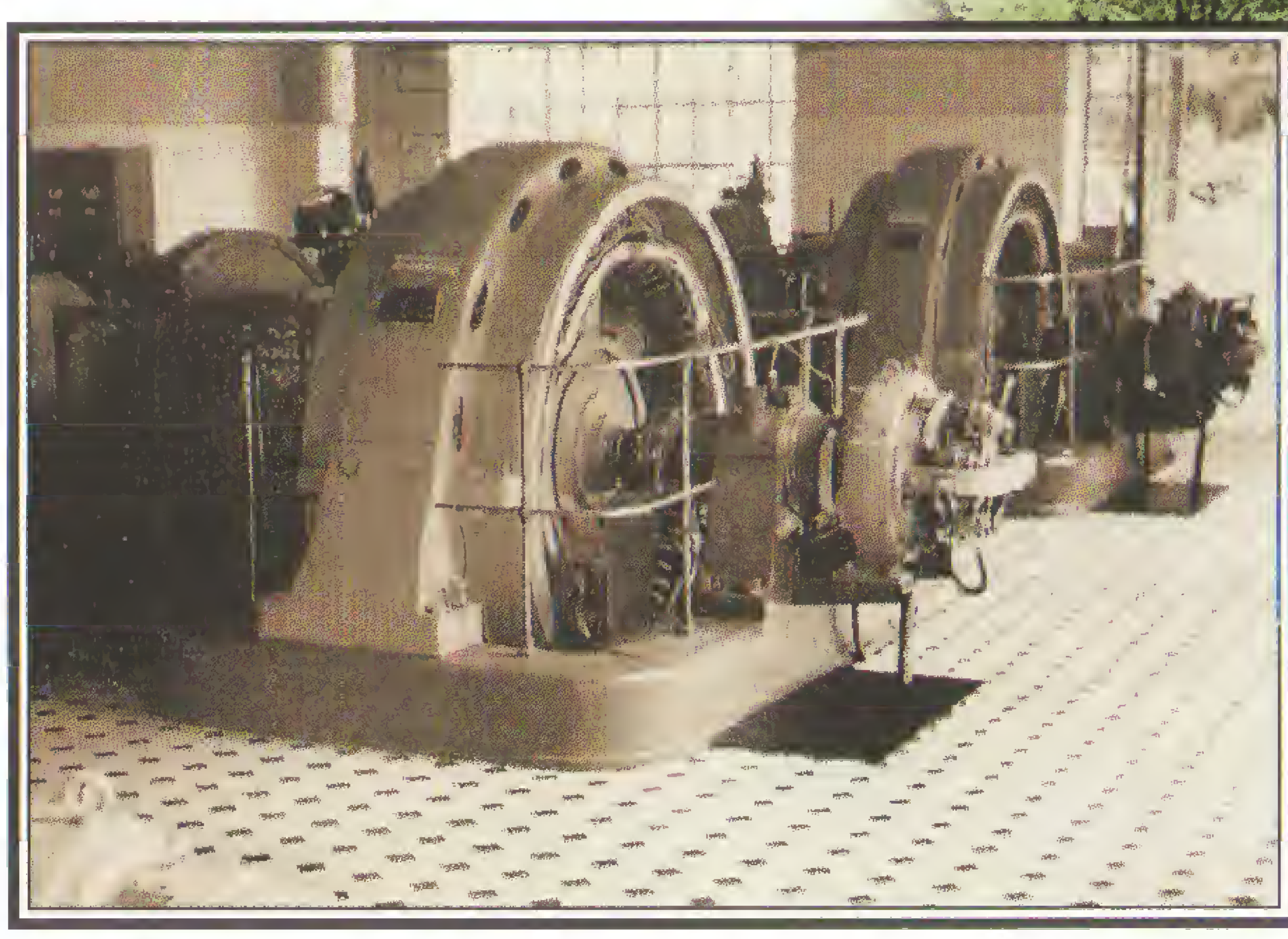
The Lom Diesel Power Plant also supplied electricity to the nearby village Golyantsi - the first electrified village in Bulgaria (1912). It is worth mentioning that this power plant was also used, to a certain extent, as a training center for power plant electricians.

Enina HPP

commissioned on January 1st 1914

still in operation

front view



Enina HPP

Machine Hall

Kazanlak was electrified by the joint-stock company "Pobeda". It built a hydro-power plant on the Enina river with the following characteristics:

- two 350 hp Pelton turbines;
- speed – 750 rpm;
- water head – 101.9 m (gross);
- three-phase generators, 2 x 300 kVA, 750 rpm, 50 Hz, 6000-6500 V, cos φ= 0.8;
- turbine efficiency 85/87.3 % depending on the load on the machines, i.e. 6-7 % higher than the efficiency guaranteed by Siemens.

The plant was commissioned in 1914. It was the first electrification enterprise in Bulgaria built with Bulgarian capital only, designed for public power supply to the town and its industry. The electric power was transmitted from the plant to the town through a 6 kV transmission line, and the low-voltage distribution network was 220/127 V.

Nikola Batsarov *(1838–1890)*
the first Bulgarian electrical engineer
graduated in 1887

The town of Varna–the "window" of Bulgaria to the world, later on to become 'the seaside capital of Bulgaria', was among the first Bulgarian towns which triumphantly received electric lighting in 1914, although the first steps in that direction had been taken as early as 1900. A number of municipality mayors, decisions and bids followed one after the other before the implementation of the project developed for the town electrification by means of a diesel power plant. The bid was won by Siemens-Schuckert. The diesel power plant had the following characteristics:

- two diesel engines–270 hp, 187 rpm each;
- Siemens-Schuckert generators (1912), 187 rpm, 5 kV, directly connected to the respective diesel engine, with 45 V exciter.

The high-voltage network (5 kV) used copper cables with 35 mm^2 phase cross section. Its total length was 8700 m. Fourteen distribution transformers were installed in concrete construction, with two 40-50 kVA capacity each, with dry insulation.

The low-voltage network (220/127 V) was a three-phase type like that in Kazanlak. In 1912–1913, when the network was constructed, Varna had a population of 43 000 people and 64 km total length of the streets 80 % of which, i.e. 48 km were electrified. The rest of the streets were not yet covered by the town plan.

The Varna DPP (diesel power plant) was commissioned on January 1st 1914, at the same time with the Enina HPP commissioning. The utility belonged to the Varna municipality.

The town of Rousse was electrified as late as 1917, by the end of the period reviewed here. Since it was a river-port town on the Danube and an important point on the way to Western and Eastern Europe, as well as a cultural center, the issue of its electrification was put forward at the very beginning of the 20th century. A decision was made for the setting up of a municipal electrification enterprise. In 1911 there were already plans for the construction of a diesel power plant and electricity distribution network in the town. A bid was announced for the purpose and it was won by Siemens-Schuckert.

Pursuant to the agreement terms and the bilateral contract the firm Siemens-Schuckert supplied and installed a diesel power plant with the following characteristics:

- 3 generating sets with four-cylinder compressor vertical diesel engines of 279 hp unit capacity, 187 rpm;
- 3 three-phase 260 kVA, 3000V, 50 Hz generators, directly coupled to the engines and the respective exciter.

The HV distribution cable network was for 3 kV voltage, with section 3×50 mm². Nine distribution transformers for 3000/220/127 V were installed in metal construction. The low-voltage network (210/120 V) was an overhead three-phase type. The voltage applied to electrical motors was 210 V, and for lighting purposes–120 V.

Due to the wars Bulgaria was involved in during the second decade of the 20th century, and World War I in particular, the implementation of the Rousse power plant was greatly delayed. It was officially commissioned in 1917.

For economic reasons, until 1921 the plant operated only at nighttime, and after that–round the clock.

Table 2 presents a summary of the electrification enterprises for public power supply in Bulgaria by 1918.

Table 2: Electrification enterprises for public power supply in Bulgaria by 1918

Enterprise		Installed capacity of the plant, hp					Annual output	
Type	Number	Hydro	Thermal	Diesel	Total hp	Total %	kWh	%
Concessions	1	3 720	7 580	—	11 300	78.55	11 000 000	89.34
Joint-stock companies	1	700	—	—	700	4.86	400 000	3.23
Private persons	2	467	—	—	467	3.24	350 000	2.84
Municipal	3	—	—	1 920	19 200	13.35	566 198	4.59
TOTAL:	7	4 887	7 580	1 920	14 387	100.00	12 316 198	100.00

In 1918 the Belgian concession was far ahead of the other electrical utilities both in installed capacity and electricity output–78.55% and 89.34% respectively.

Table 3 presents a comparison of investments by type of enterprise.

Table 3

Investments by 1918	Leva	%
Concessions	7 720 000	72.86
Joint-stock companies	460 000	4.35
Private persons	300 000	2.83
Municipal	2 114 377	19.96
TOTAL:	10 594 377	100.00

Until the end of World War I (1918), although the Bulgarians were convinced of the usefulness of electrification and that without it no significant progress in the country was possible, most of the towns except for the above-mentioned five ones, continued to use oil lamps for indoor and street lighting (street lanterns).

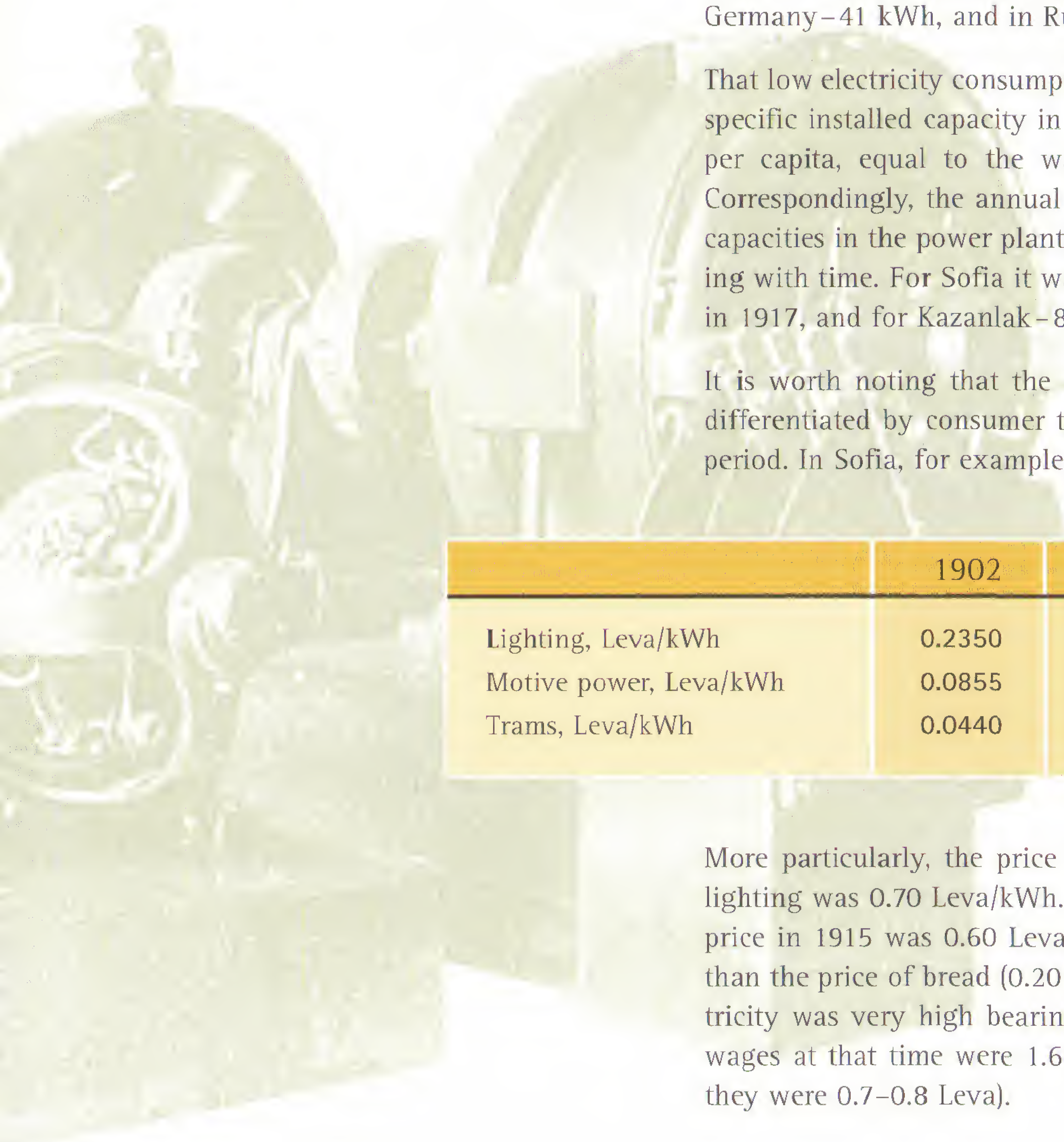
Electricity Demand Level

During the period of local electrification electricity demand level could be considered only in relation to several electrified towns and villages, where, except in Sofia, electricity was mainly used for lighting purposes. Sofia had the highest specific electricity consumption per capita, as shown below:

	1910	1916
Population of the city	102 812	144 000
Lighting, kWh per capita	12.6	15.0
Street lighting, kWh per capita	7.9	7.2
Motive power, kWh per capita	15.4	12.5
Trams, kWh per capita	11.9	45.5

Before the end of World War I the average specific electricity consumption in Kazanlak for all purposes did not exceed 45 kWh per capita, and in Varna it ranged between 5 and 8 kWh per capita. This low figure was due to the irregular operation of its diesel power plant.

The overall electricity generation in the country by 1913 (at the time of the Balkan wars) was estimated at about 110 million kWh and 2.2 kWh per capita on the average for the country. At the same time the electricity consumption per capita in the USA was 156 kWh, in Germany – 41 kWh, and in Russia – 14 kWh.



That low electricity consumption corresponded to the low specific installed capacity in the power plants – 50÷60 W per capita, equal to the wattage of an electric lamp. Correspondingly, the annual utilization ratio of installed capacities in the power plants was low, although increasing with time. For Sofia it was 670 h in 1901 and 1074 h in 1917, and for Kazanlak – 830 - 1000 h, respectively.

It is worth noting that the electricity tariffs were quite differentiated by consumer types and varied during that period. In Sofia, for example, they were as shown below:

	1902	1910	1916
Lighting, Leva/kWh	0.2350	0.3709	0.41
Motive power, Leva/kWh	0.0855	0.0967	0.18
Trams, Leva/kWh	0.0440	0.0973	0.09

More particularly, the price of electricity for household lighting was 0.70 Leva/kWh. For Kazanlak the electricity price in 1915 was 0.60 Leva/kWh, or three times higher than the price of bread (0.20 Leva/kg). That price of electricity was very high bearing in mind that the workers' wages at that time were 1.6–2 Leva (for female workers they were 0.7–0.8 Leva).

2 Regional Electrification 1919-1947

The transition from local to regional electrification in Bulgaria resulted from tracing out the general lines of its development after World War I. For the purpose, a number of acts and plans were developed, the more important of which included:

- Water Syndicate Act and General State Program for Waters (1920);
- Commission with the Ministry of Agriculture and State Property set up to work out a General Electrification Plan of Bulgaria (1929–1933);
- Decree on the Electrification of Bulgaria (1935);
- Competition for the General Conceptual Design for the Electrification of Bulgaria announced by the Ministry of Public Buildings, Roads and Public Utilities (1940) which resulted in a final, approved General Conceptual Electrification Plan of Bulgaria in 1941;
- Two-year Plan of National Economy Electrification (1946–1947).

Construction of large power plants, overhead transmission lines and distribution substations was typical of the regional electrification during that period. Its development was related to two main things: larger investments and better organized steps for the General Plan implementation.

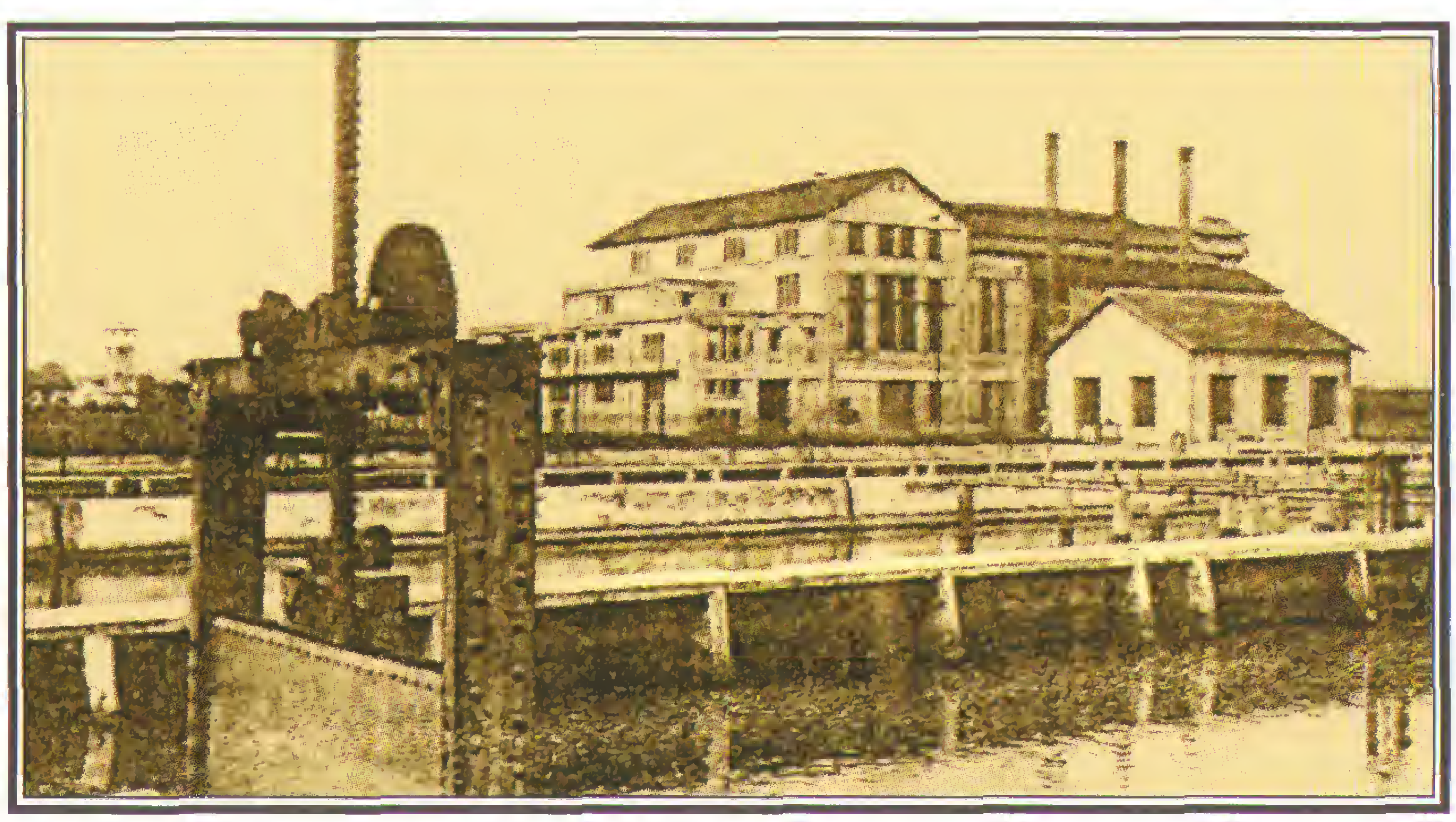
Table 4: Relative investments for power plants in Bulgaria

Owner	% by years			
	1931	1939	1944	1948
The State	8.36	7.66	32.40	63.80
Municipalities	11.5	24.39	36.20	13.85
Water syndicates and cooperatives	14.47	30.10	6.40	4.82
Popular banks	4.81	4.90	4.20	5.18
Joint-stock companies and private persons	60.86	32.95	20.80	12.35
TOTAL	100.00	100.00	100.00	100.00

However, both directions faced significant obstacles, since at that time electrification services were distributed among three ministries: Ministry of Commerce, Industry and Labor; Ministry of Public Buildings, Roads and Public Utilities; Ministry of Agriculture and State Property. The lack of coordination among them, as well as the narrow departmental interests impeded electrification to a great extent. Moreover, initially private capital had the largest share in the construction of power plants.

The Union of Bulgarian Engineers and Architects contributed greatly to the leading of a correct and unified state electrification policy by developing a proper development strategy in that field.

The electrification regions in Bulgaria in the 1930's and 1940's were determined in conformity with the existing administrative regions, as follows: Sofia, Plovdiv, Stara Zagora, Bourgas, Varna, Rousse, Pleven, Vratsa and Gorna Jumaya (Blagoevgrad).



Kourilo TPP

commissioned in 1927

front view

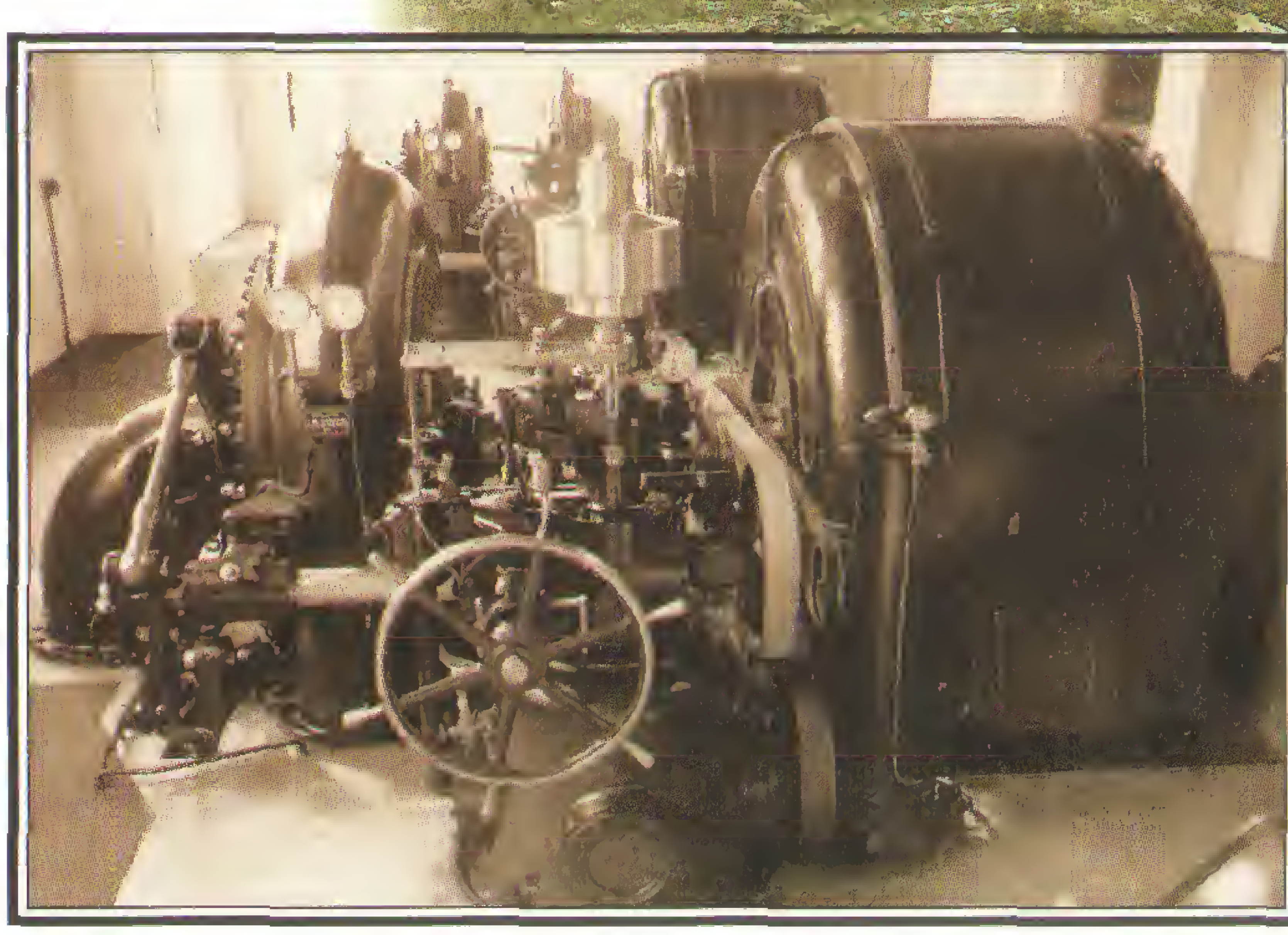
The electrification of the Sofia Region developed at the highest rate due to the availability of hydro-power and coal resources. After World War I, there was a huge influx of refugees from the enslaved Bulgarian lands (Macedonia, Thracia, Western Regions), a large part of whom settled down in Sofia. The Belgian concessionaire had to build "Kourilo" thermal power plant-within 12 km of Sofia (1927) for providing new electrical capacity

for the capital city. Initially, 2x6400 kW units were installed, and then in 1930–a third unit, so the overall plant capacity reached 19 200 kW. The plant was connected to Sofia through 35 kV overhead transmission lines. Unfortunately, the boiler capacity of the plant was insufficient, so it could hardly reach 14 500 kW. Small-sized (6-16 mm) brown coal from Pernik was used as fuel.

Pastra HPP

commissioned in 1925

overall view



Pastra HPP

Machine Hall

The capacity and electric power generated by the Kourilo TPP supplemented the hydro-power plants of the company and Sofia municipality, that is why Kourilo had low annual utilization ratio which did not exceed 1000 h. The Kourilo Plant, as well as Pancharevo HPP operated at 53 Hz frequency till the commissioning of Mala Tserkva HPP in 1934 when they switched over to a standard 50 Hz frequency.

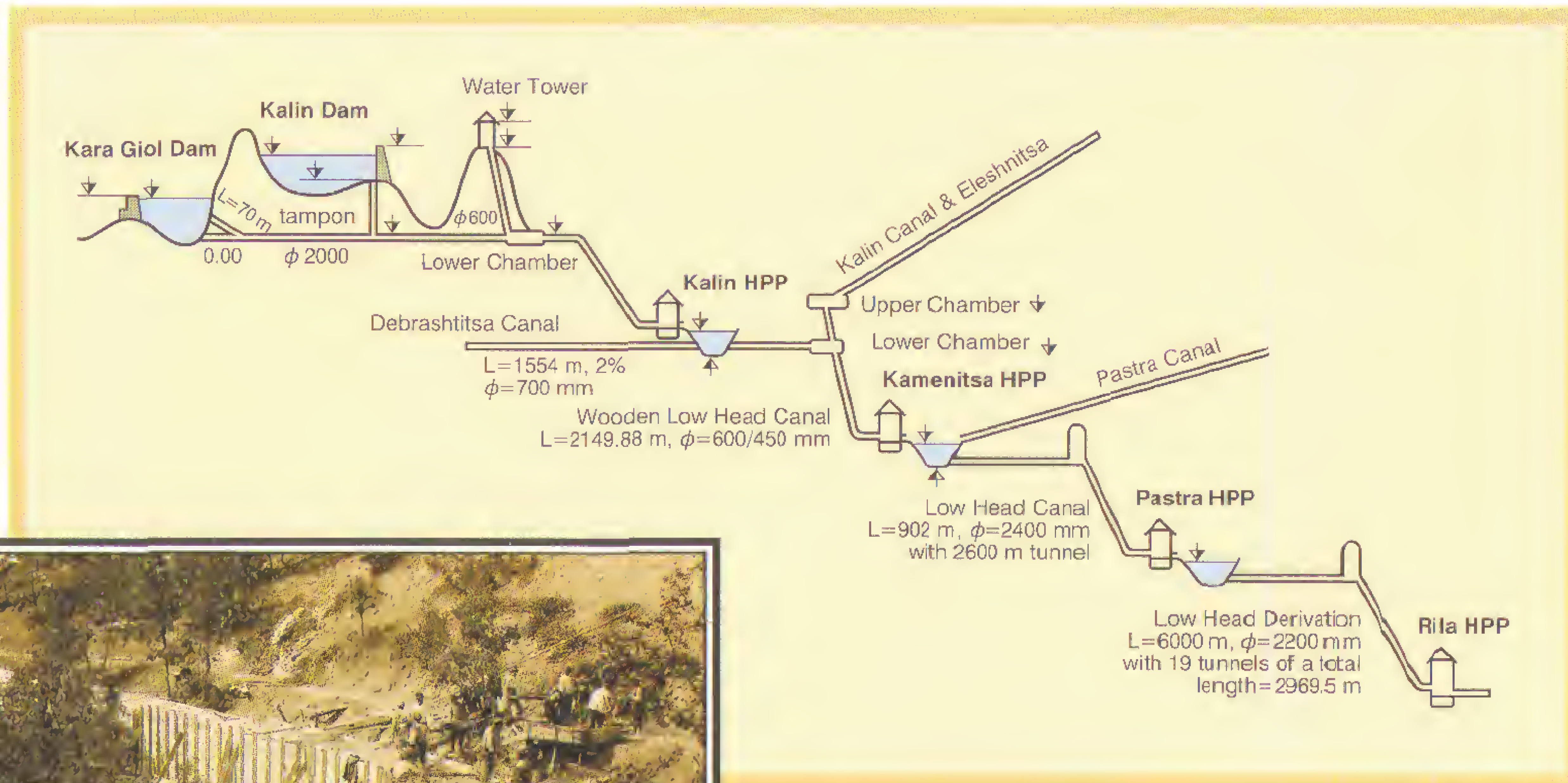
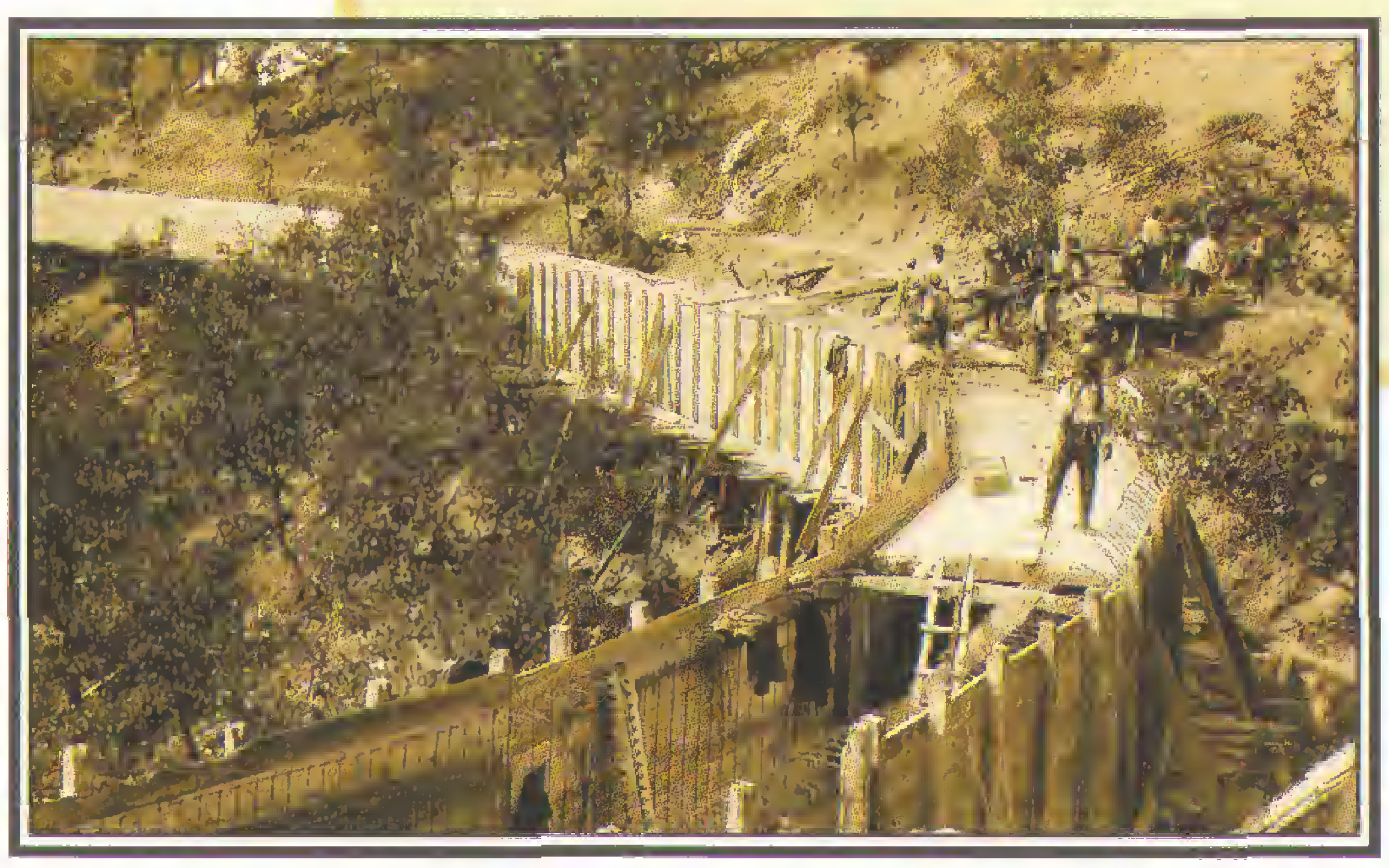


Fig. 2: Elevation diagram of the Rila Cascade



Construction

of the reinforced concrete rectangular section gutter to the Pastra HPP

A significant electric power source in that electrification region was formed by the hydro-power plants of the Rila Cascade owned by Granitoid J.S.C.: Pastra, 5520 kW (1925); Rila, 6400 kW (1929); Kamenitsa, 3375 kW (1940) and Kalin, 4500 kW (1948). The electric power generated in these plants was transmitted to Sofia and its electrification region at 60 kV.

Rila HPP

commissioned in 1929 front view

In 1926 a new 60/15 kV distribution substation-"Orion", was built in the north-west part of the capital city. By it Granitoid set the beginning of regional electrification in Bulgaria.

Reinforced concrete

round section

gutter to the Rila HPP

For the purposes of water supply to the capital city, in 1933 the Rila Aqueduct was built, starting from the Rila Mountain (the highest peak of which is 2925 m), with three hydro-power plants erected along it: Simeonovo, 6280 kW (1927, 1934); Mala Tsarkva, 4200 kW (1934), and Beli Iskar, 7700 kW (1957). The electric power from the first two plants was transmitted to Sofia at 35 kV, and from Beli Iskar – at 110 kV.

Fig. 3: Plan of Granitoid J.S.C. transmission lines, 1934

Pernik TPP

commissioned in 1929

front view

The Pernik State Mines were the third large electrification enterprise in South-East Bulgaria. The needs of the mines consumption and the region demand were met by the construction of 6000 V Pernik TPP with 2x4000 kW units, commissioned in 1929. Using cheap waste brown coal, the plant was designed to reach 50 000 kW in the future.

15/0.4 kVA Distribution Transformer

belonging to Granitoid

built during the 1930's

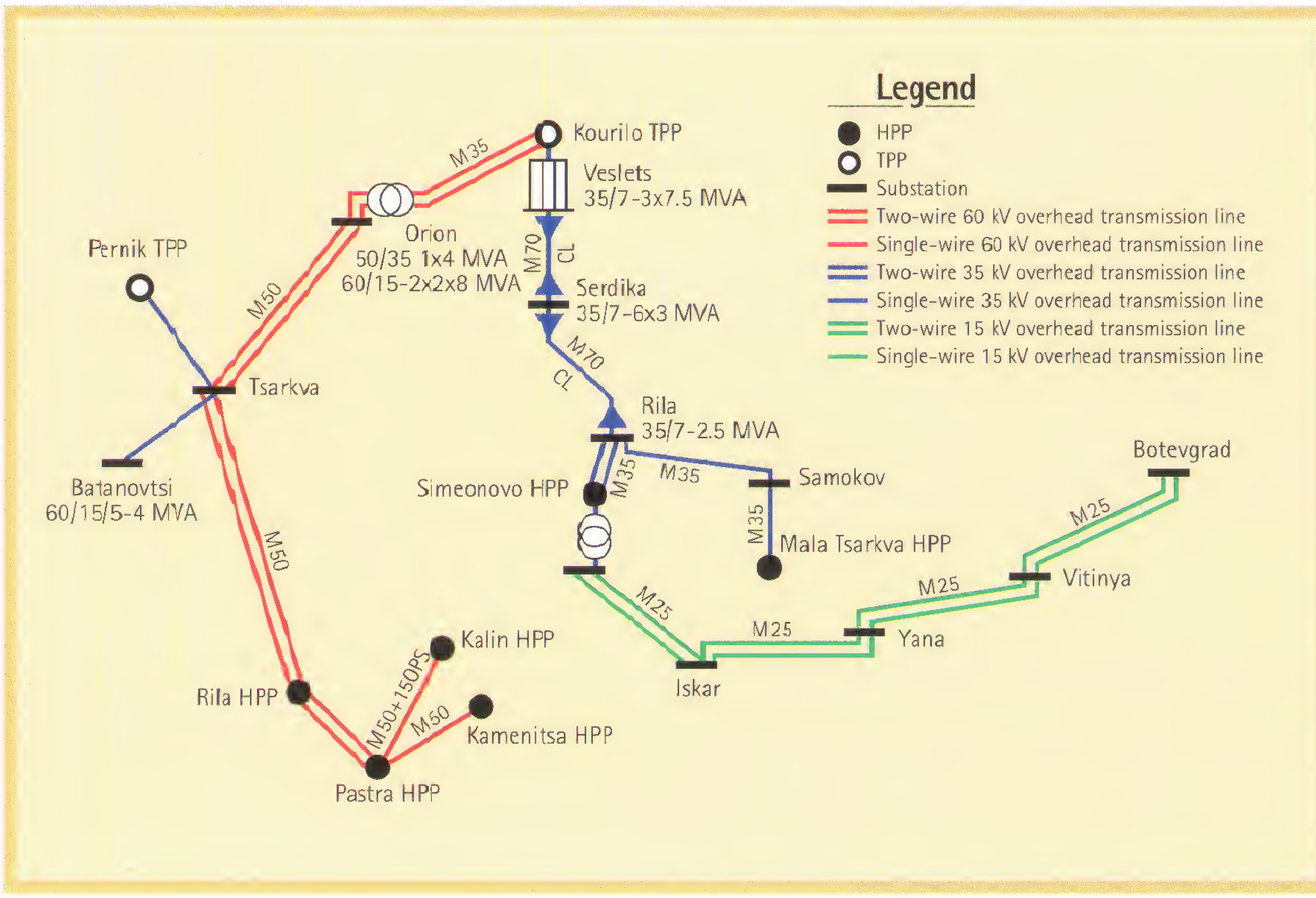


Fig. 4: Electrification plan of Southwest Bulgaria by 1944, diagram

60/35/15 kV Orion Substation

in operation since 1926

(photo 1927)

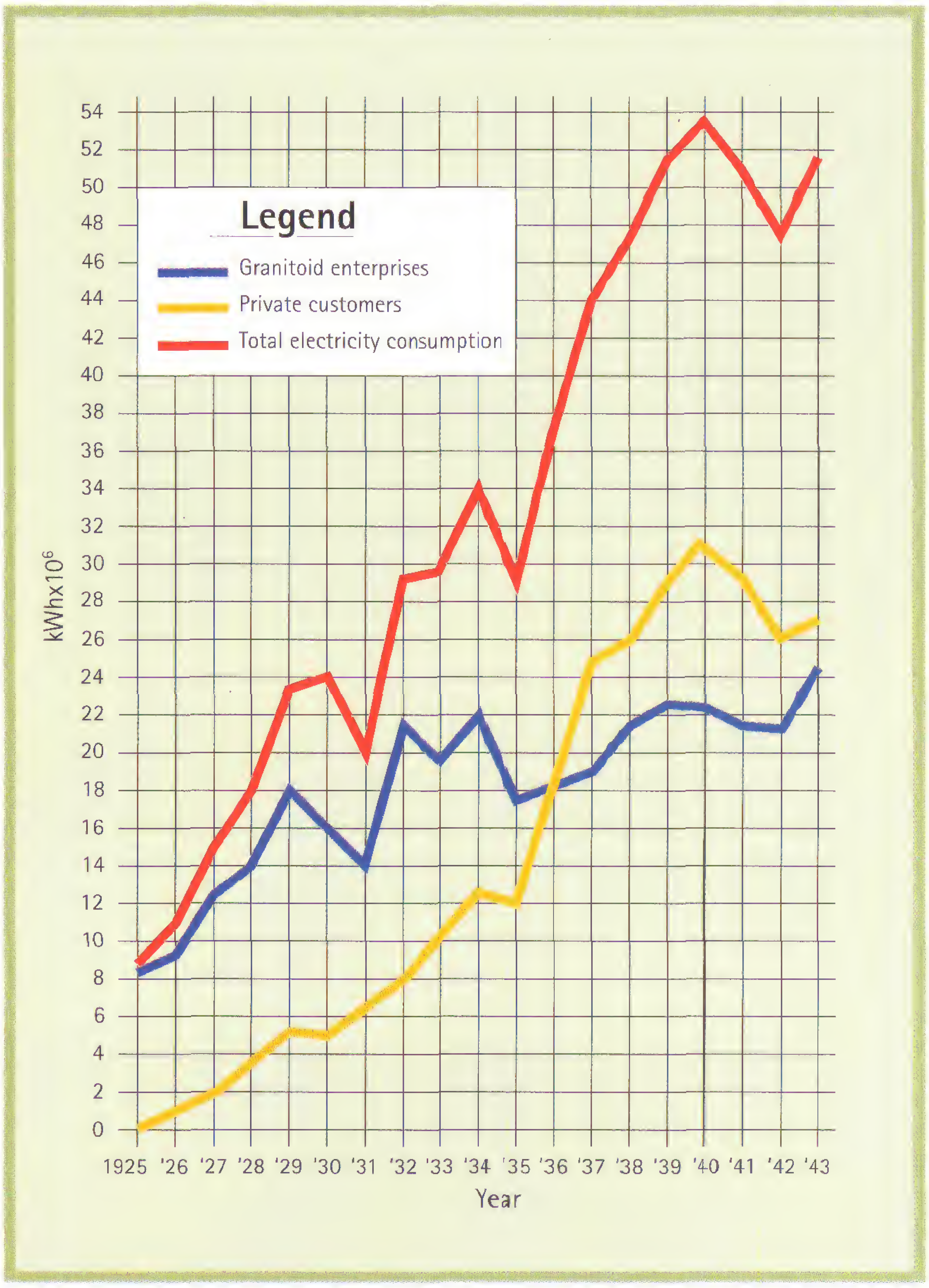
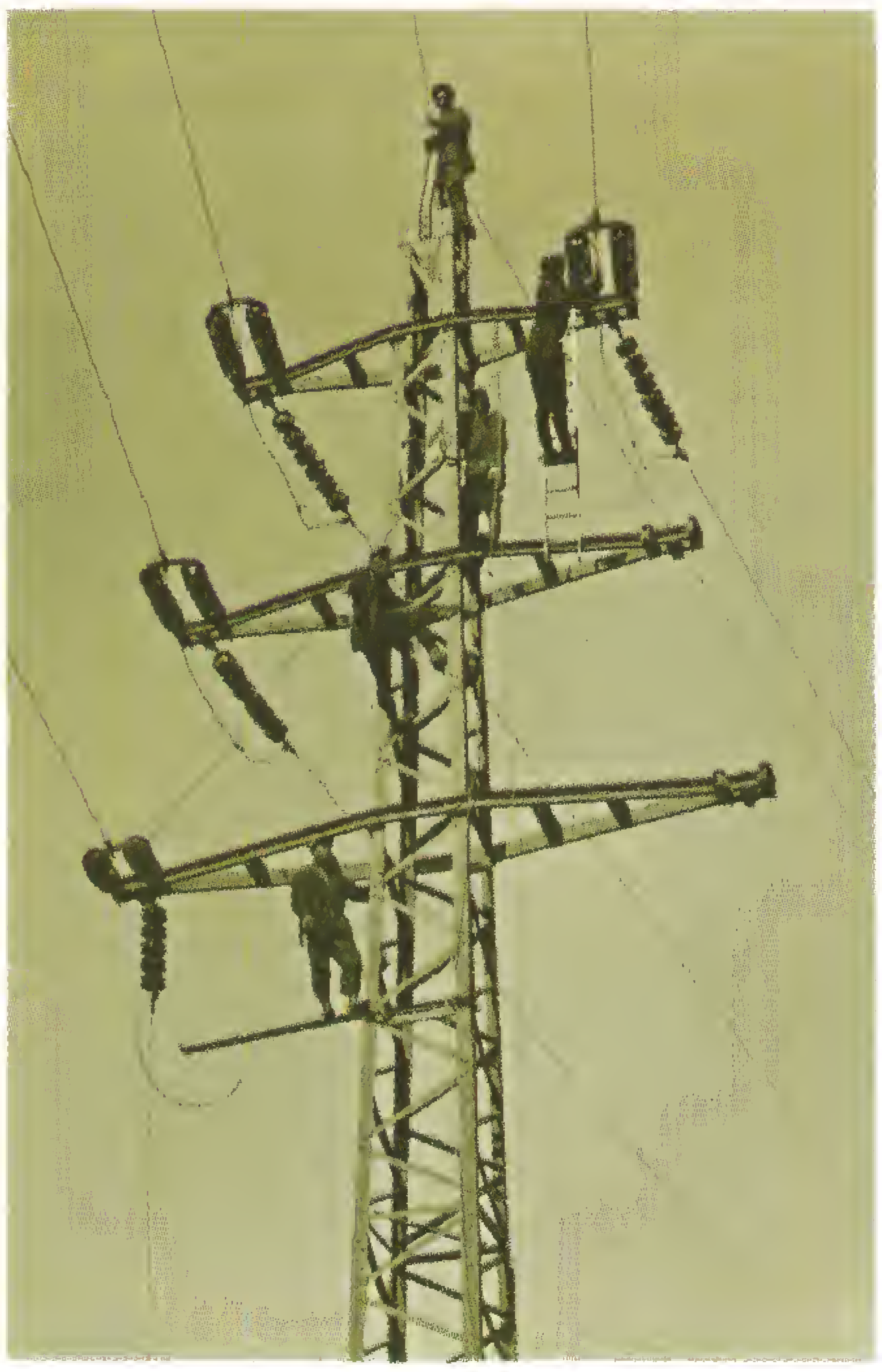


Fig. 5: Development of Granitoid electricity consumption 1925–1943

The specific electricity consumption in the Sofia Region in 1943 was as follows: in Sofia and the villages annexed to it–167 kWh per capita, and in the rest of the region–121.8 kWh per capita at average specific electricity consumption in Bulgaria 45 kWh per capita.

Fig. 6: Gross electricity consumption in the Sofia Electrification Region

Reconstruction of the 35 kV Pastra-Orion overhead transmission line to 60 kV under tension, 1929



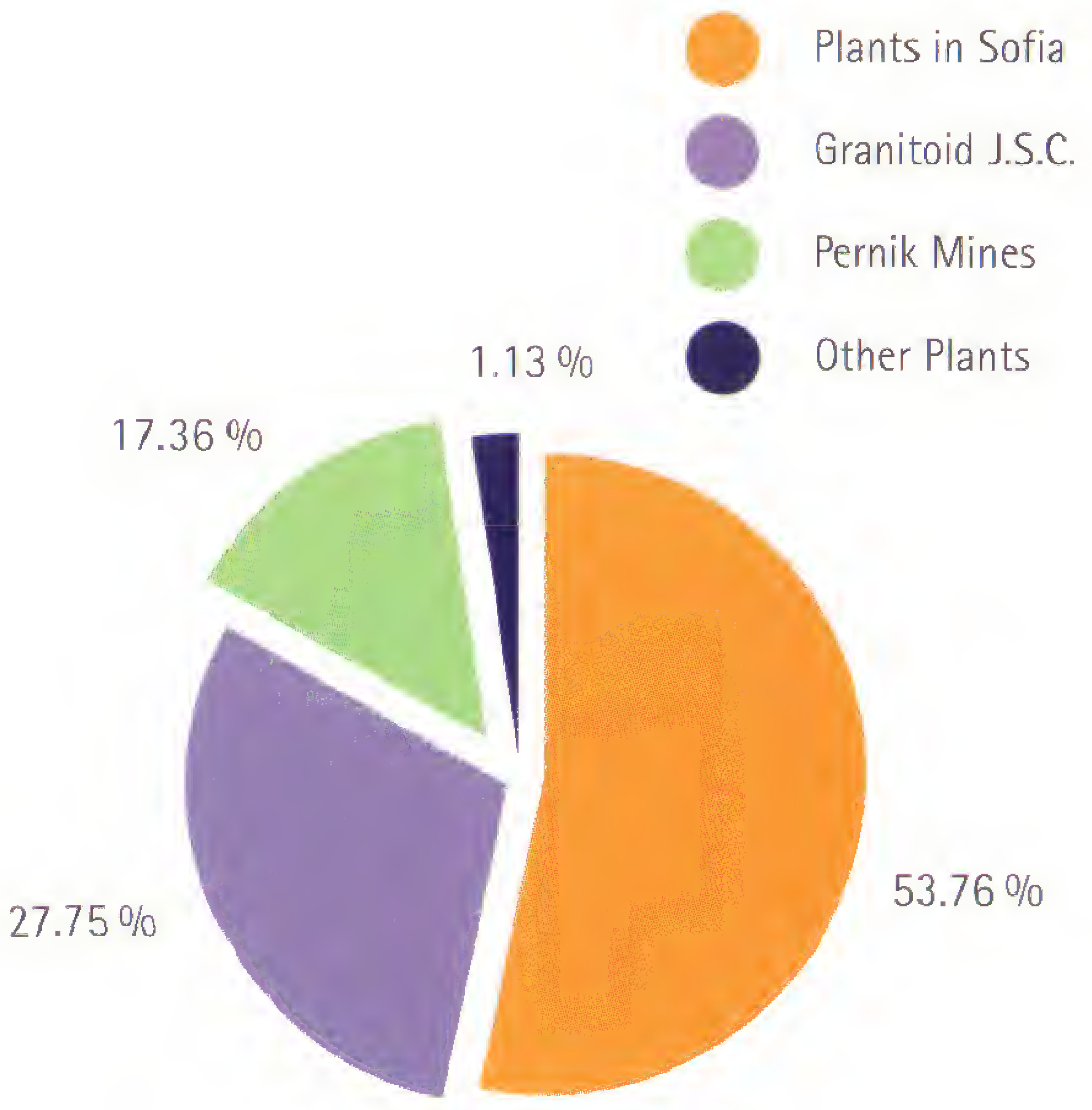
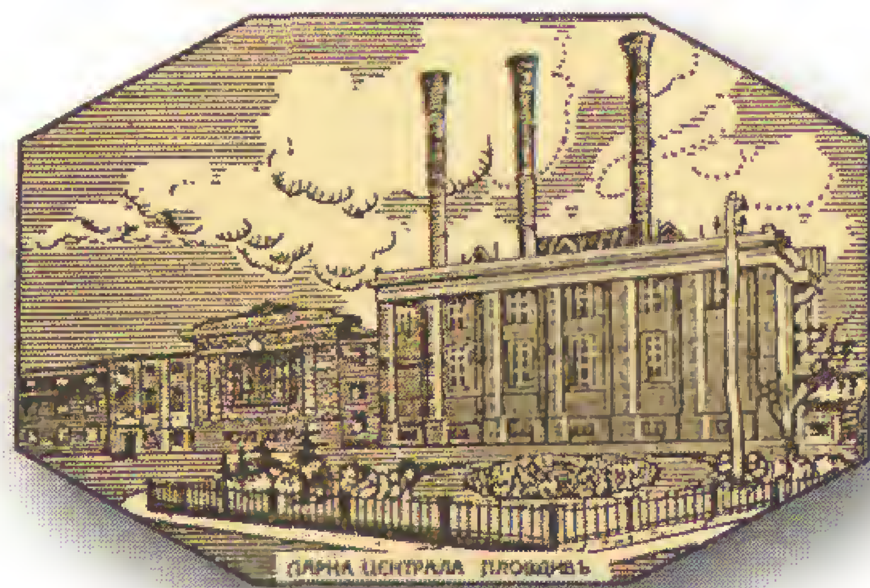
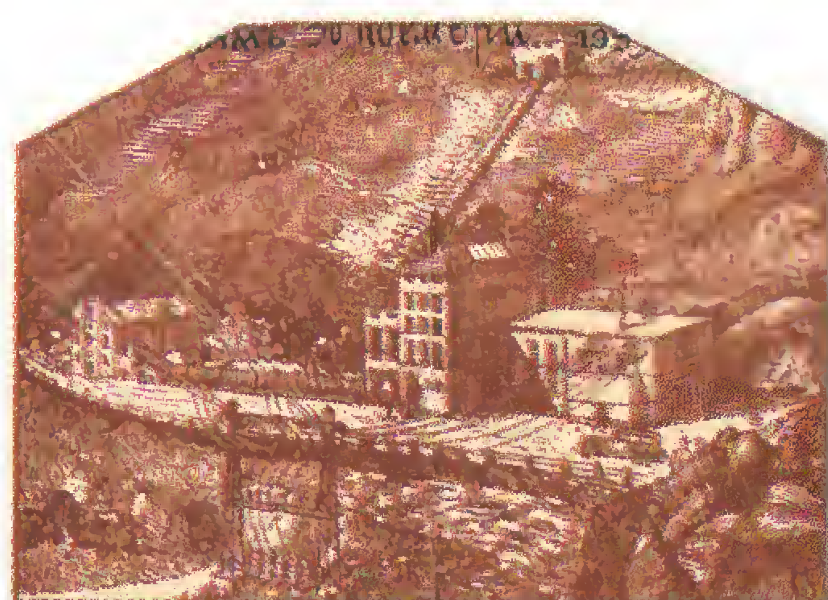


Fig. 7: Allocation of the electricity consumption in the Sofia Electrification Region, 1943

Plovdiv Electrification Region





The Plovdiv Electrification Region was formed and built exclusively by the Vacha Power Plant Water Syndicate. It was the largest water syndicate in Bulgaria where considerable state capital was invested at the very beginning (1920).

The machines of Vacha HPP (later on called HPP Krichim) were supplied by Alstom, France: 2x3500 kW, 6.2 kV, directly coupled to the turbines. The water diversion tunnel was 4754 m long, with 3 m diameter and throughput capacity 5000 l/s. The plant was commissioned in 1933, after a 10-year period of construction.

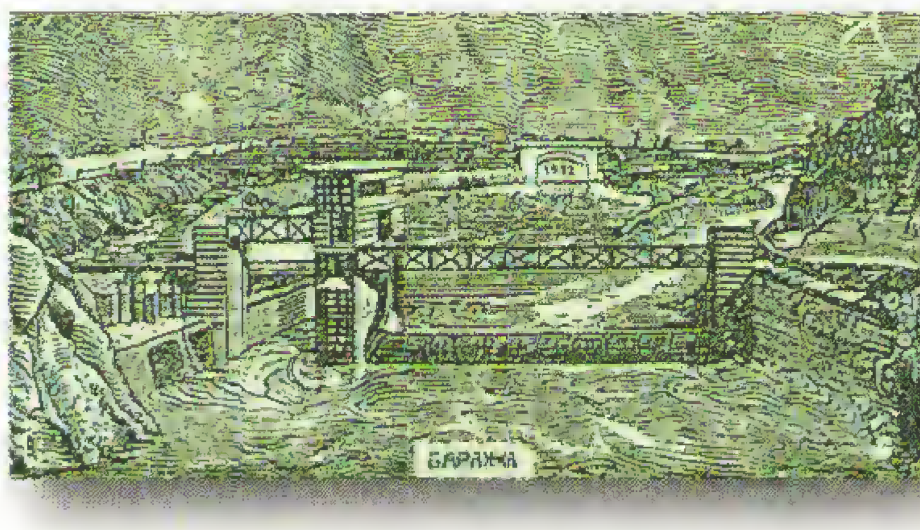
Due to the delayed completion of the Vacha HPP, in 1927 a thermal power plant with two 850 kW units with generator voltage of 2 kV was built in Plovdiv.

Prior to the construction of the Plovdiv TPP – property of the Water Syndicate, some small power plants had been used for public power supply in several towns in that region, including: Plovdiv, Peshtera, Karlovo, Trigrad, Chepelare. Only Karlovo HPP was an exception with capacity of its turbines 1x1500 hp and 1x490 hp.

The Vacha Water Syndicate also built 60 kV overhead transmission lines from Krichim to Plovdiv and from Krichim to Pazardjik, total length of 45 km, as well as 60/15 kV substations in Plovdiv and Pazardjik (1927).
The same syndicate built a large 15 kV distribution network the length of which reached 1071 km in 1939, as well as 780 km low-voltage network, and 394 distribution

The old Vacha HPP

commissioned in 1934



transformers–15/0.4 kV, with a total capacity of 21 703 kVA. At that time the number of consumers reached 29 326, 15 658 of which were members of the Syndicate.

Dozens of various enterprises in the light and food-processing industry, as well as hundreds of irrigation pump stations in the fertile fields around Plovdiv and Pazardjik were supplied with electricity.

Stara Zagora Electrification Region

During the first three decades of the 20th century ten small individual power plants were built in Stara Zagora-the center of that electrification region. Some of them also supplied electricity for street and residential lighting.

It was only in 1930 when Svetlina Co. Ltd. was established. On the basis of various options studied, it electrified the town by means of the Vulkan TPP (located in the village of Chernokonyovo, nowadays a suburb of Dimitrovgrad) through a 35 kV overhead transmission line and a 35/6 kV substation. In 1933 Stara Zagora had a population of 30 000 people and the electric load at the nine 6/0.4 kV distribution transformers was equal to 380 kW, 240 kW of which were used for residential lighting, 20 kW for street lighting, and 120 kW as motive power.

At the beginning of the forties Stara Zagora, respectively its 35/6 kV substation, was connected to the regional Maritsa I Power Plant (nowadays in Dimitrovgrad), and the electricity supply from the Vulkan company was terminated.

In order to meet the growing demand of Kazanlak which had been electrified as early as 1914 by electricity supply from the Enina HPP, in 1924 Pobeda constructed a diesel power plant with 200 hp engine and 175 kVA, 6300 V generator. Five years later, in 1929, a second, more powerful diesel unit with 400 hp engine and 350 kW, 6300 V generator were installed. And in 1937 a third unit with a 780 kW, 6300 V generator was installed at the Enina HPP.

The other big towns in the region were electrified by small diesel power plants not exceeding 500-600 kW capacity, as follows: Sliven (1928), Yambol (1928), Nova Zagora (1929), Haskovo (1934), Chirpan (1937), Kardjali (1939), and a number of other towns and villages.

Bourgas Electrification Region

The electrification of Bourgas–the regional center, started in 1918 with the installing of one steam engine and a 100 kW dynamo at the sea port. After that some more small electrical facilities were installed. Much later, in 1927, the town was electrified by means of the thermal power plant of the Cherno More Mine owned by the Budeshte J.S.C. through an 11 km, 15 kV overhead transmission line and a 15/6 kV substation. In general, at that time, according to the instructions of the Ministry of Public Buildings, Roads and Public Utilities, the distribution voltage in a town could not exceed 6 kV. A new joint-stock company "Adree" was established as a daughter company of Budeshte J.S.C. for supplying Bourgas with electricity.

At that time the Adree power plant had one unit of 750 kW. In 1932 and 1937 it was extended by a second 2000 kW unit and a third 4000 kW unit respectively, all of them for 3 kV, as well as its step-up substation 3/15 kV.

Later on, in 1946 a 20 kV overhead transmission line "Adree–Straldja" was constructed, and Straldja nodal plant, on its part, was power supplied from the 60/20 kV Yambol Substation.

A few smaller power plants were built in the Bourgas electrification region, the installed capacities of which did not exceed 500 kW. They supplied power to some factories, as well as generated electricity for the public power supply system.

In general, the length of the 3–20 kV electric lines in the region a minor part of which were cable lines, was as follows: in 1936–188 km, in 1944–298 km, and by 1950–756 km. 3-20/0.4 kV distribution transformers were connected to these electric lines, the number and capacity of which were as follows: in 1944–99 distribution transformers of 8660 kVA; in 1950–223 distribution transformers of 18725 kVA. In the period examined here no 60 kV overhead transmission lines were built in the Bourgas Electrification Region.

The other towns in that region were electrified as follows: Aitos (1930), Karnobat (1930), Pomorie (1931), Sozopol (1931), Nessebar (1932), Michurin (1932). The first electrified village was Aheloy (1936). Before 1944, 22 settlements were electrified in that region–towns and villages, the latter after 1940.

Varna Electrification Region

After the end of World War I the electricity supply in Varna gradually returned to normal. Varna DPP (diesel power plant) operated from 7.00 till 12.00 at daytime and from sunset till midnight. Due to the small loads, only one machine ran in the morning, and both machines - at nighttime.

In 1922 the number of consumers amounted to 1873 with electric meters and 1730 without electric meters, or a total of 3603 consumers at town population of 43 000. These figures show that a large part of the population in Varna was not yet electrified - a situation typical of other electrified towns in Bulgaria. In 1930 a municipal lighting business enterprise was established in Varna. And in 1937 two small separate power plants were also commissioned - one on the Aqueduct from the Batova river, and the other at "Prince Boris" Factory, with a total capacity of 500 kW.

Varna DPP

commissioned in 1914

front view

The electrical load increased quite rapidly, and in the evenings the generators voltage fell from 5000 V to 4500 V for covering the peak load. At the same time, the redemption time of the loan drawn by the enterprise for the first three diesel generators was prolonged - the debt to the bank amounted to 1 414 637 Leva and it was returned as late as 1949.

A fourth diesel generator set was also supplied, but its capacity was quite small – 500 kW. The disputes whether a new thermal power plant should be constructed or electricity should be supplied by Adree J.S.C.–Bourgas, went on. A special commission assigned to carry out thorough investigations, presented 3 options of development of Varna electricity supply, as follows:

I. Extension of the existing DPP;
II. Supply of electricity from Adree-Bourgas, through a 95 km 60 kV overhead transmission line;
III. Construction of a local thermal power plant.

The third option was recommended and approved. Through a tender procedure, at the first stage a 2200 kW unit was procured from Czechoslovashki Colben-Danek, Prague (1944), and after that – a second 5000 kW unit, so the total capacity became 7200 kW (10 000 hp). The Varna DPP became a large regional power plant for its time, in compliance with the decisions of the first general electrification plan of 1941.

Varna DPP
Machine Hall

The Varna Municipality received a loan from the Electrification Fund covering 30% of the resources initially needed for the construction of a new thermal power plant. Against that loan, the Municipality undertook the obligation to electrify six districts including the newly liberated Dobrudja (1940).

The civil works on the regional 20 kV overhead transmission lines to the value of 80 million Leva continued simultaneously with the Varna DPP construction. Their length reached 500 km, and sixty five 20/0.4 kV distribution transformers to the cost of 50 million Leva were connected to them.

Thus, by the end of World War II, the Varna electrification region recovered and almost all towns were electrified, but electric lighting still had to reach the villages.

Shoumen Electrification Region including Rousse Region

Rousse was the only town in the Shoumen electrification region electrified before World War I (1917). Another exception was Silistra which was electrified in 1936 by means of a DC diesel power plant, when Dobrudja was still under Romanian rule.

The growing electricity consumption in Rousse required that the Rousse diesel power plant should be extended by a new diesel unit – a 600 hp engine from the Graz factory, and a 470 kW Siemens generator (1926). So, the plant reached 940 kW total installed capacity, and the town's demand for electricity was completely met.

In 1936 a business enterprise – "Rousse Electricity Supply", with its own budget was established. The Ministry of Public Utilities assigned to it the electrification of other towns in that region. For the purpose, in 1941 a thermal power plant with one 2000 hp turbine and a 1400 kW generator was built on the site of the Rousse DPP. Some small industrial and local power plants with capacity not exceeding a few hundreds of kilowatts were also used.

Rousse DPP

commissioned in 1917

front view

Quite an early electrification was carried out in Razgrad in 1930 by the construction of a 130 kW diesel power plant and later, in 1933 a 350 kW extension to it. Koubrat was also electrified in 1930, the village of Shtraklevo in 1933, etc.

Shoumen, as the main town in the region, was electrified by means of a 270 hp diesel power plant with a 180 kW, 6000 V generator, and five 6/0.4 kV distribution transformers (1927). So, 34 years after the first electric bulb was lit up in Shoumen (at the brewery in 1893), the beginning of electrification in the town was laid. Later on, the Shoumen DPP was extended by a second 240 kW unit (in 1929) and a third unit with a Wechsel engine, operating as both diesel and gasogen engine (1939). The war time when there was a shortage of diesel fuel necessitated the use of such an engine that could operate using charcoal gas. For the purpose, during the next few years (1942) the enterprise bought 500 dca of forests in the mountains around Preslav for the production of about 1 800 000 kgf charcoal.

With a view to regional electrification, the General Directorate of Electrification in Bulgaria with the Ministry of Electrification, Waters and Natural Resources completed the construction of a 20 kV overhead transmission line: Varna-Provadia-Shoumen, thus in 1947 the two power plants were connected for electric power exchange.

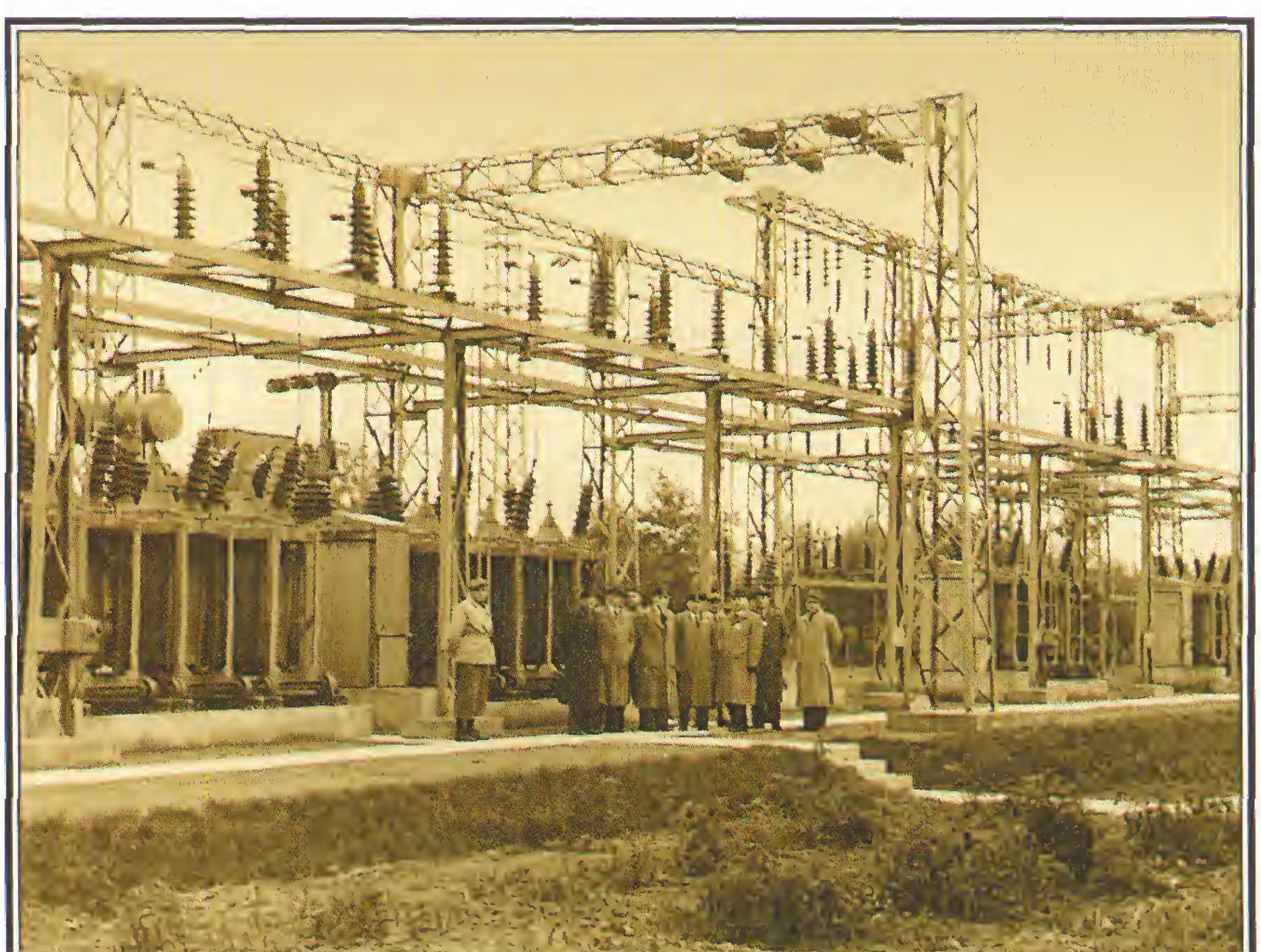
Besides the electrification of towns and villages in the region, one of the high-priority objectives of the Shoumen electricity supply enterprise was the electrification of the water-supply pump stations in the dry Ludogorie region and in whole Dobrudja–9 districts as a whole by that time. By 1944, 85 settlements of the 157 planned were supplied with water.

Gorna Oryahovitsa Electrification Region

The Gorna Oryahovitsa Electrification Region was formed around a centre situated at the Gorna Oryahovitsa railway junction due to its geographical and infrastructure conditions. In that fertile and active region, a leading role in electrification was played by Gabrovo where a significant textile industry was developed at the beginning of the 20th century by followers of Racho the Blacksmith and Ivan Hadjiberov.

Several water syndicates (WS) were set up in that region: Malusha (1922), Gramadata (1926), Rositsa (1921), Yantra (1921), as well as joint-stock companies and cooperatives (Bedek, Videlina), and a dozen of industrial enterprises that intended to meet their own electricity demand, as well as to provide public power supply. The leading role in that respect belonged to Gramadata WS–Gabrovo. In 1926 it built a reliable diesel power plant of the same name with initial generator capacity of 166 kW, 6 kV, thus laying the beginning of the overall public power supply in Gabrovo. Only a few years later, a new 450 hp diesel engine was supplied to Gramadata DPP.

Several other electrical utilities were also built in the region: Malusha HPP with two units, 420 hp and 160 hp (1940), Batoshevo 1 HPP on the Rositsa river, 625 kW (1926), and Bedek TPP in Tryavna with unit capacities 600 kW (1931) and 2000 kW (1935), as well as a 60 kV overhead transmission line to Maritsa East 1 and 60/20 kV Gabrovo Substation (1945).



Gorna Oryahovitsa Substation

60/20 kV switchyard (1941)

Pleven Electrification Region

The Pleven Electrification Region was developed much later, during the 1940's when the North Bulgaria Electrification Directorate was established in 1940 and transformed into General Directorate of Electrification in Bulgaria on May 8th 1944.

In Pleven, the administrative center of the region, the issue of electric lighting was raised in 1906, then in 1907 and again in 1911 (a project was drawn up), however, electrification there was begun in 1919. At that time a dynamo installed in a mill was also used for supplying electricity lighting to the neighboring houses.

Large-scale electrification in Pleven began in 1927 when the Pleven DPP was constructed and commissioned with two diesel-engine units of 200 hp each. The Plant was extended by 460 hp in 1930 and 1200 hp in 1949. It operated at 6 kV. The same was the town distribution voltage and that of the 6/0.4 kV distribution transformers.

Later on (1950-1951) near the Pleven-West railway plant, a 110/20 kV regional substation was built in order to provide connection to the regional electrification system of the country. That set the beginning of an orderly development of the Pleven Electrification Region.

110/20 kV Distribution Substation Cherven Bryag-
the 20 kV indoor switchgear under construction

It is worth noting that near Loukovit, on the Zlatna Panega river, the first dam in Bulgaria was built. It was given the name of the river and had 1.2 million m^3 storage capacity and a power plant on it, with two units of 480 kW total capacity, commissioned in 1938.

Mezdra Electrification Region

In the beginning the Mezdra Electrification Region developed as part of the Pleven Electrification Region. Mezdra became a regional center owing to its geographical situation and position as a railway junction. As early as 1909 a small diesel engine was installed in the railway depot to drive a dynamo for electric lighting of the railway plant (until 1928). The town was electrified by means of a small local plant in 1927, and from 1935 on it already had the Rosa hydro-power plant on the Iskar river, connected to the Sofia electrification system through a 20 kV overhead transmission line and 15/20 kV autotransformer (1947).

The first 110 kV overhead transmission line in Bulgaria was laid between Kourilo and Mezdra. It was designed in 1942 by the Czech ex-Skoda Works-Pilzen and constructed by the same firm. Due to the political events in Bulgaria the construction was stopped after 1944 and the transmission line was completed by Bulgarian specialists in the summer of 1949. Initially it operated at 35 kV. In 1947 the first 110 kV substation in Bulgaria was built- 110/20 kV Mezdra Substation. Initially it received 35 kV current from the Kourilo power plant. Later on in 1950 the substation, with one 5000 kVA autotransformer, was set in parallel with the Sofia system through the 110 kV overhead transmission line. At the same time, voltage was supplied to the 110 kV overhead transmission line from Mezdra to Cherven Bryag-the second sector of the 110 kV overhead transmission line ring pursuant to the General Plan.

A number of 20 kV overhead transmission lines stretched from the Mezdra substation and thus the Mezdra electrification region was formed (1947). The towns that had been earlier electrified through local power plants, such as: Montana (Ferdinand, 1936), Vratsa (1927), Lom (1912), Byala Slatina (1929), Kozloduy (1933), at that time were united into an interconnected 20 kV system.

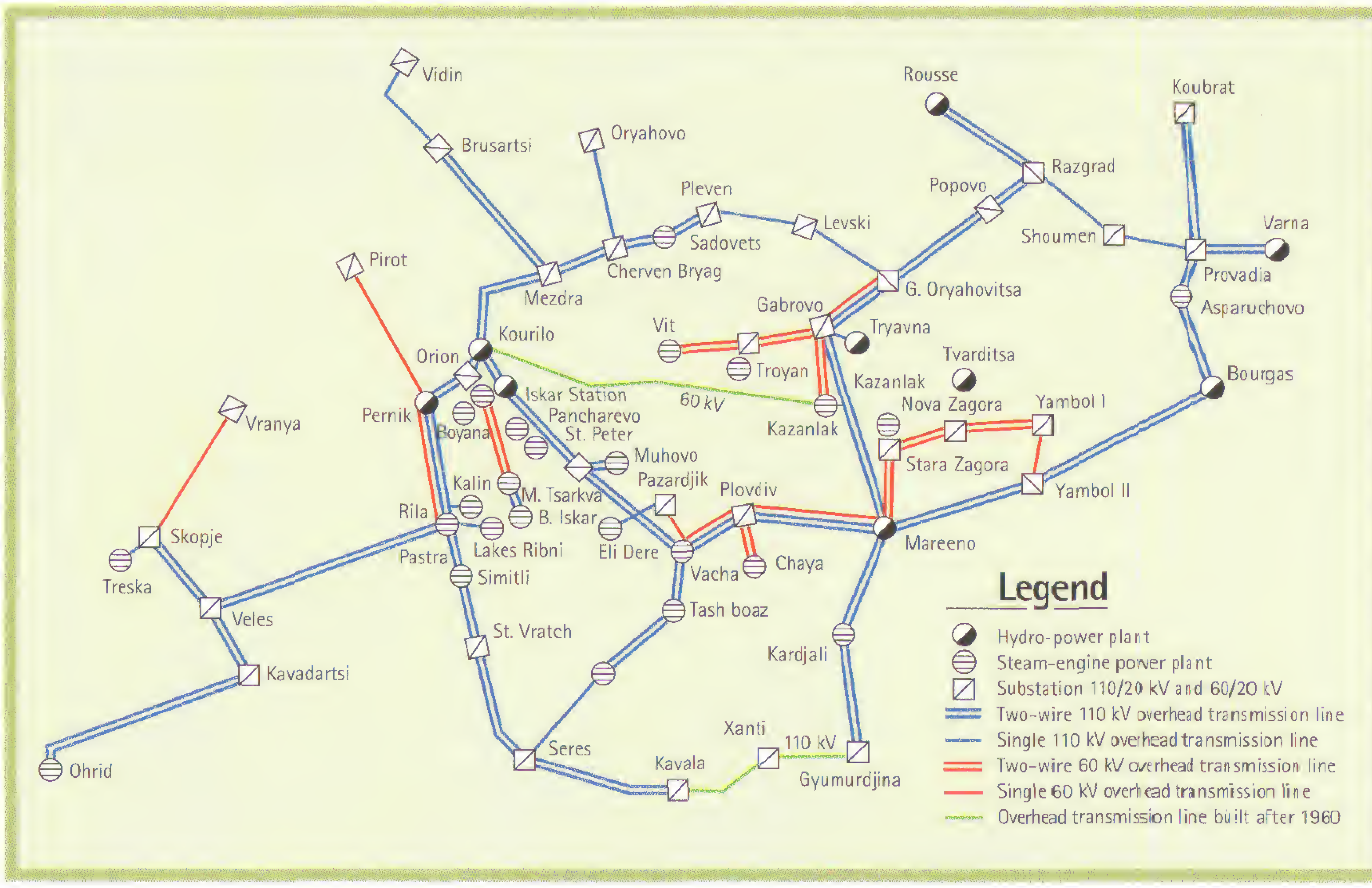


Fig. 8: Electrification system diagram according to the First General Conceptual Electrification Plan of Bulgaria (within the Bulgarian borders at that time), 1941

During the 1940's – the years of World War II (1939 – 1945) significant large-scale changes occurred in Bulgaria connected with its economic, state and political development, including electrification.

In 1945 Bulgaria had 119 public utility power plants with a total installed capacity of 110 968 kW and electric power output of 401 261 000 kWh, or 57.8 kWh per capita on the average. 94 of all these power plants had less than 1000 kW capacity; 56.8 % of their capacity consisted of state and public power plants.

Before the end of 1947, seventeen 35-60/15-20 kV substations were installed with total capacity of 86.4 MVA. The 60 kV transmission lines had a total length of 480 km, and the 35 kV transmission lines – 166 km. In 1950 an interconnection transmission line with Romania – "Rousse-Giurgiu", was commissioned. It consisted of a 60 kV cable line across the Danube.

There was a wide variety of medium distribution voltages–3, 5, 6, 7, 15 and 20 kV. This led to the same variety of the distribution transformers network. Their low voltage was a three-phase one, 380/220 V everywhere, and only in Rousse, Varna and Kazanlak it was 210/110 V, and in Sofia–150 V, three-phase one for AC without neutral tapping.

By 1947, 2724 distribution transformers of total installed capacity of 269 545 kVA were built in Bulgaria, or 100 kVA per distribution transformer on the average. The length of the low-voltage network was 13 116 km or 4.81 km/per distribution transformer.

In 1946 a new electrification authority was established–the Ministry of Electrification, Waters and Natural Resources which put an end to the lack of coordination between the electrification services. The same Ministry, and the General Directorate of Electrification in Bulgaria, in particular, developed a two-year electrification plan (1946–1947) involving an intense construction in that area. An Energy Syndicate of all electrification enterprises was also established making no difference between the forms of ownership.

The increasing demand for engineers led to the opening of a Higher Technical School in Sofia in 1942, with a Faculty of Architecture and Civil Engineering which was transformed into State Polytechnic (State Technical University) in 1945. At that time the number of M.Sc. electrical engineers was about 500 (1946).

The Union of Bulgarian Engineers and Architects contributed a great deal to the development of all bills on the electrification of Bulgaria, as well as to the opening of the Higher Technical School and to the establishment in 1932 of the Bulgarian National Committee of Energy with the World Committee of Energy created in 1924.

3

Interconnected Electrification System

Overall Electrification of the Country 1948-1970

3.1. Generating Capacities

The 23-year period examined herein was marked by a campaign of the communist regime established in Bulgaria after 1944. The acts, decrees and ordinances adopted at that time brought about radical changes in all spheres of life in the country. The most important among them are:

1. Act on Industry, Bank and Mine Nationalization and Electrification (24.12.1947);
2. Cooperation of Agricultural Lands and Establishment of Agricultural Cooperatives (CLAC);
3. Giving priority to heavy and energy-intensive industries;
4. Adoption of a special Electrical Industry Act in connection with the Nationalization Act which came into effect on January 1st 1948. The new act superseded the act issued by the General Directorate of Electrification in Bulgaria as well as the Acts of the Elprom Syndicate, the Water Syndicates, the Acts on construction of the Rositsa and Topolnitsa Dams, and the Act on Heat and Electricity Supply Joint Ventures. On January 1st 1948 the Ministry of Electrification, Waters and Natural Resources was transformed into two ministries: Ministry of Electrification and Amelioration (MEA), and Ministry of Mines and Mineral Resources (MMMR).

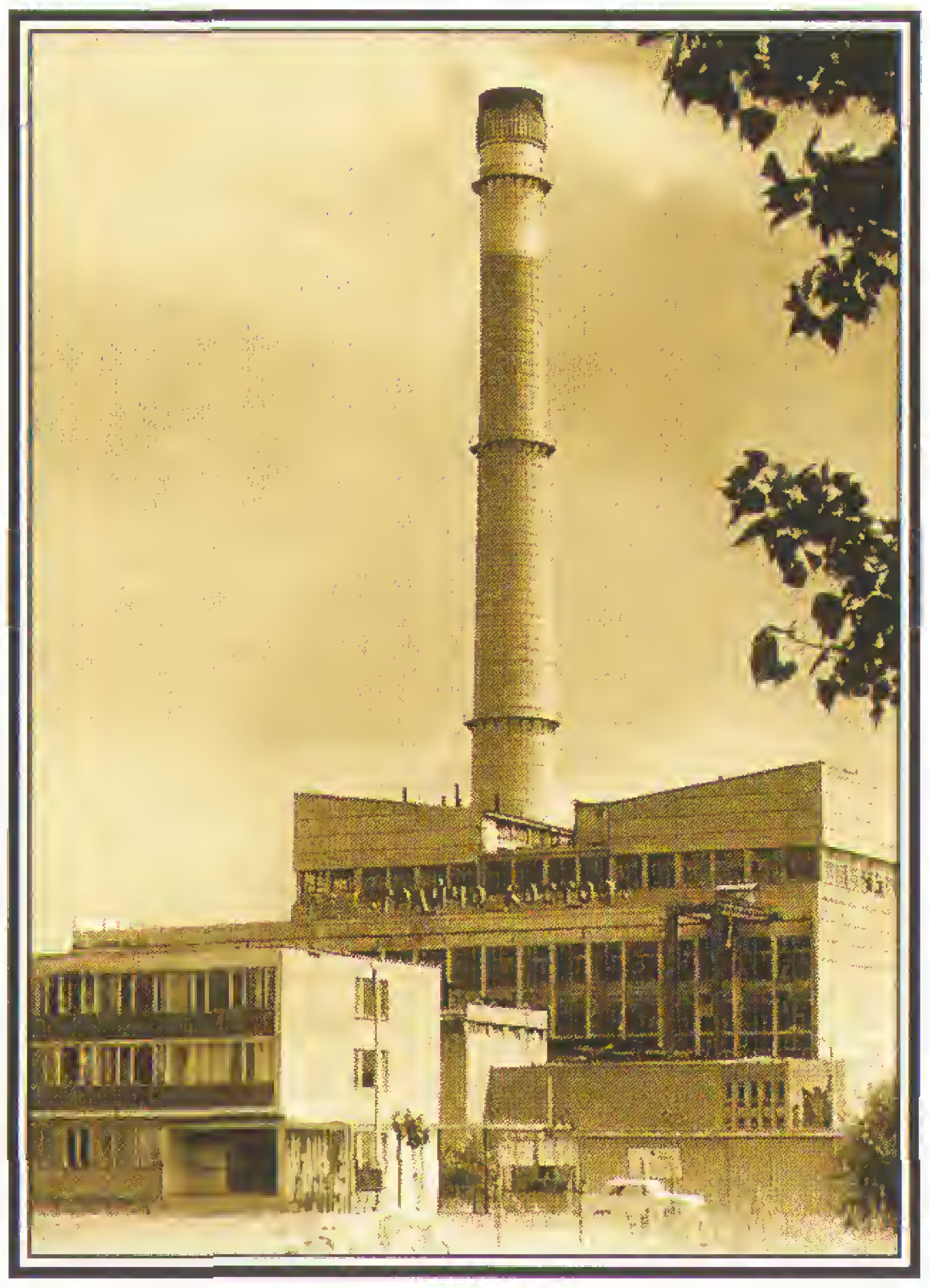
Sofia TPP

commissioned in 1949 (the first heating plant in Bulgaria) front view

5. A Decree of the Council of Ministers of 02.04.1948 led to the establishment of enterprises with the Ministry of Electrification and Amelioration:

- **Energoobedinenie** – a state economic group for electric power generation, transmission and distribution, including the power plants and electrification regions each one as a separate accounting unit.
- **Elprom** – a state economic group encompassing all enterprises in the field of electrical industry.
- **Energostroy** – a state enterprise for erection, upgrading and development of power plants, transmission and distribution networks.
- **Energohydroproject** – state designer's bureau specialized in working out designs for any electrical or amelioration projects.

6. Constant administrative changes, including the electrification sector, as well, aiming to appoint politically convenient non-professionals at high posts.



Sofia-East TPP
commissioned in 1964
front view

All these major changes affected, to one extent or another, the development of electrification and, most of all, the nationalization of electrification. At the same time we should not neglect the fact that the Bulgarian electrical engineers welcomed the nationalization of electrification because for many years they had championed this kind of electrification finding it as the only feasible form for its accelerated development.

Five-year plans were worked out for a total development of the Bulgarian economy. In respect to the electrification projects, their terms were always fulfilled on time.

A specialized Science Research Institute of Electrification and Electrical Industry was established in 1954.

The fast development of the electrical projects construction resulted in early completion of the target projects under the 1941 General Conceptual Electrification Plan. Thus Energohydroproject developed a Second General Plan approved in 1955. It applied to a short term period (1962); however, further on it underwent a number of updates to meet longer term goals.

After the nationalization of electrification, the first larger public-utility thermal power plants (TPP) were constructed, as well as power plants meeting the needs of some individual industrial works. Table 5 presents the technical data of these first power plants.

Table 5: Thermal power plants constructed during the period 1948–1970

Plant Name	Year of commiss-ioning	Installed capacity MW 1st stage	Extension MW	Total MW	Remark
I. DISTRICT HEATING PLANTS					
Nadezhda (Sofia)	1949	2 x 6	2 x 6 1 x 12 3 x 25 1 x 50	161	
Republica (Pernik)	1952	2 x 25	2 x 25	100	
Sofia–East	1964	4 x 30	1 x 66	186	
Sliven	1969	1 x 30	—	30	
II. PUBLIC-UTILITY POWER PLANTS					
Maritsa-3 (Dimitrovgrad)	1954	2 x 25	1 x 120	170	
Maritsa East-1	1960	4 x 50	2 x 150	500	
Rousse-East	1964	2 x 30	2 x 110 2 x 60	400	
Maritsa East-2	1966	4 x 150	2 x 210 2 x 215	1 450	325 m flue stack
Varna	1969	3 x 210	3 x 210	1 260	

The fuel basis of the district heating plants was gas and fuel oil (Nadezhda and Sofia-East), and brown coal (Republica and Sliven), and that of the power plants was lignite coal; only Varna TPP used imported steam coal and gas, and Rousse TPP–imported steam coal only.

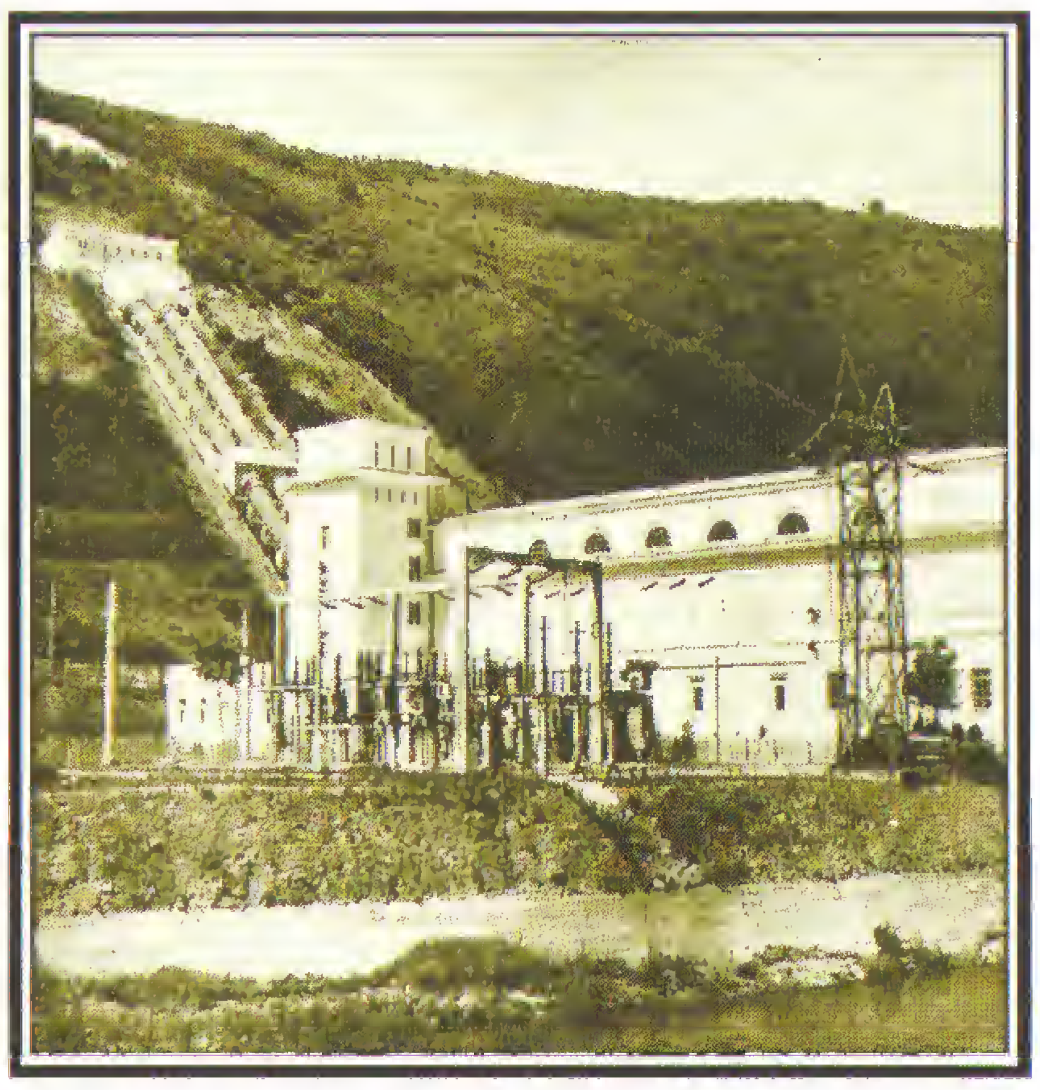
The largest thermal power plants in Bulgaria were built in the Maritsa East lignite field, including Maritsa East 2–the largest thermal power plant on the Balkan Peninsula, with the highest flue stack in Europe (325 m).

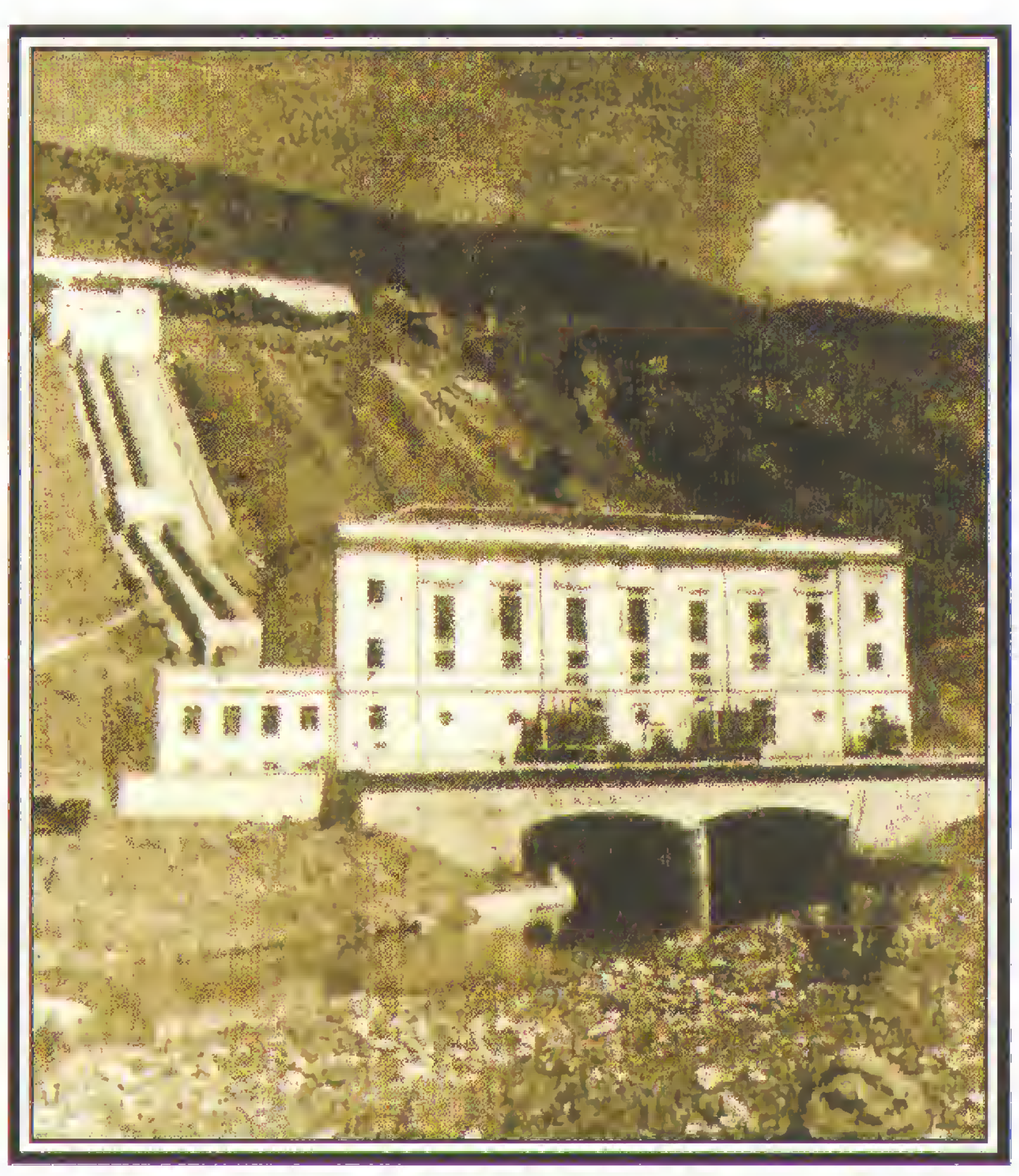
By the end of the 1950's there were wide discussions about the priority development of thermal power plants after a number of hydro-power plants and cascades had already been built or studied for construction.

Passarel HPP

commissioned in 1956

overall view





Kokalyane HPP

commissioned in 1956

overall view

However, the smaller investments needed for thermal power plants, in spite of their higher annual costs compared to hydro-power plants, gave a green light to their construction.

The building of large industrial works and industrial complexes necessitated the construction of a number of industrial thermal power plants with installed capacities not exceeding a few tens of megawatts. These were: Gorna Oryahovitsa TPP, 2x6 MW (1961); Kremikovtsi TPP, 3x25 MW, 50 MW and 12 MW (1963); Neftochim TPP–Bourgas, 25 MW, 12 MW, 60 MW (1964); Devnya TPP, 5 units of total capacity 22 MW (1954); thermal power plant of the Stara Zagora Nitrate Fertilizer Works, 4x6 MW (1963); thermal power plant of the Petrochemical Works Plama–Pleven, 60 MW (1969); thermal power plant of the Chemical Works–Vidin, 2x25 MW (1969); Sviloza TPP–Svishtov, 2x60 MW (1970); Chimco TPP–Vratsa, 2x25 MW, as well as a number of other small thermal power plants belonging to some factories.

Bulgaria is quite deficient in hydro-power resources. Moreover, these resources are unevenly distributed over its territory. The technically utilizable hydro-power potential of the country at that time amounted to 15 billion kWh, or about 1700 kWh per capita, and the cost effective–to about 10 billion kWh.

With respect to water run-off, the country was divided into three catchment areas with different energy potential: Aegean (66.2%), Danubian (30.1%), and Black Sea (3.6%).

In 1949–at the very beginning of the period reviewed here, a special hydro-engineering and hydro-power construction authority was established. It constructed separate hydro-power plants, hydro-power systems, and complete hydro-power cascades. At the same time the Installation Works Authority with its subdivisions carried out the installation of the power plants. That was already a complete cycle of work of the Bulgarian experts.

Table 6 presents the technical indices of all hydro-power cascades, respectively of the separate hydro-power plants, as well as the year of their commissioning. Within a few years of such construction and installation works the Bulgarian specialists accumulated considerable experience which was applied later on in projects abroad.

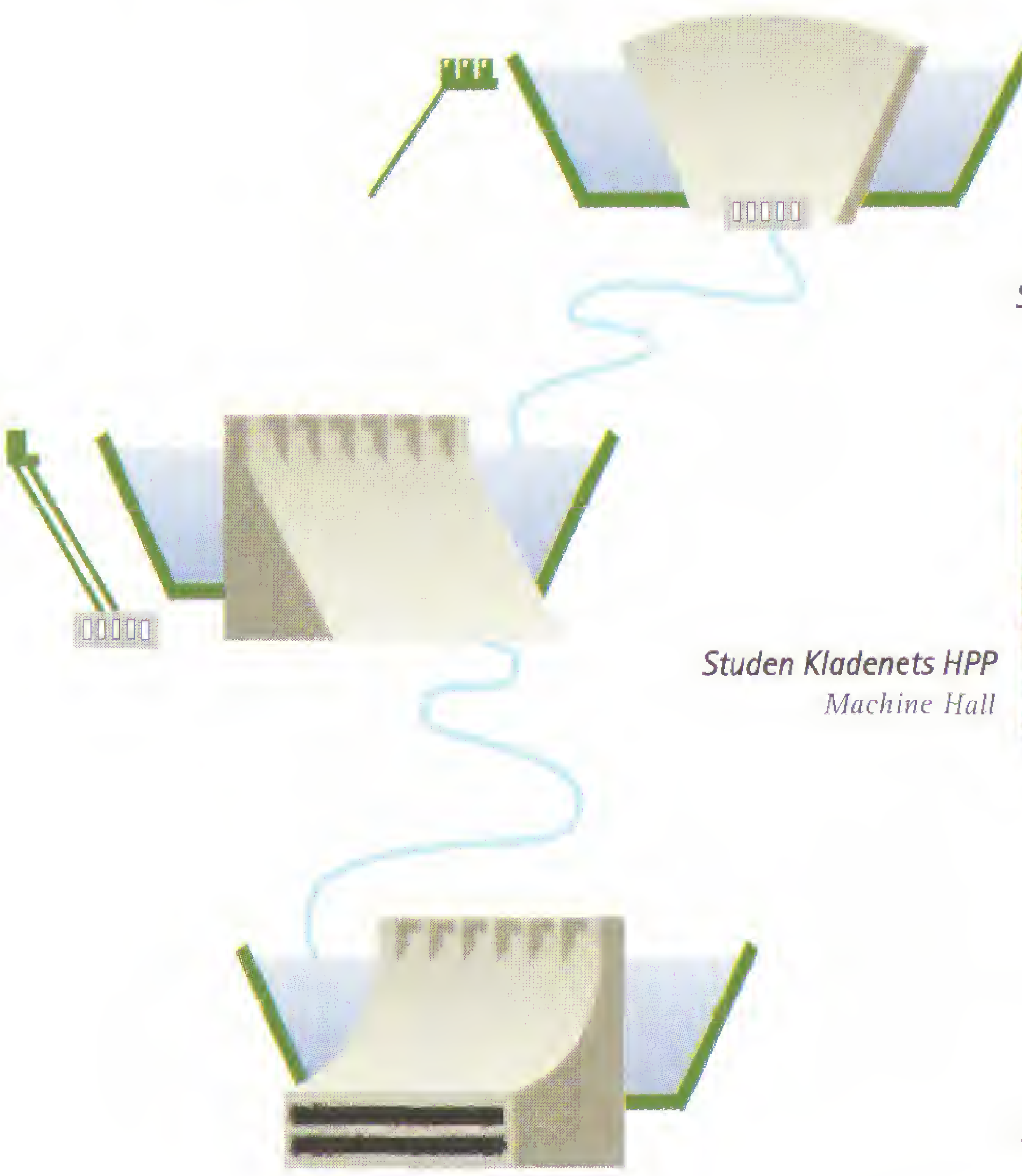
Table 6: Hydro-Power Cascades

Cascade, Hydro-Power Plant	Storage capacity m^3	Commis-sioned in year	Head m	Flow Rate m^3/s	Units pcs./type**	Capacity MW	Output mln.KWh
Petrohan Cascade	—						
Klisoura HPP	—	1953	115	4	2F	3.5	16
Barzia HPP	—	1955	250	2.8	2P	5.6	30
Petrohan HPP	—	1957	509	1.9	2P	7.8	33
Iskar Cascade	598	1956					
Simeonovo HPP	—	1928	456	2.1	3P	6.3	49
Mala Tserkva HPP	—	1934	300	3.5	3P	7.7	43
Beli Iskar HPP	—	1956	355	6	2P	16	42
Pasarel HPP	—	1956	103	33	2F	33	77
Kokalyane HPP	—	1956	92.5	30	2F	22.4	73
Batak Cascade	378						
Batak HPP	—	1959	400	13.6	4P	40	162
Peshtera HPP	—	1959	580	26	5P	125	444
Aleko HPP	—	1959	265	30	3F	63	205
Arda Cascade	864						
Kardjali HPP	—	1963	80.5	162.4	4F	106	165
Studen Kladenets HPP	—	1958	59.5	120	4F	60	217
Ivailovgrad HPP	—	1965	44	270	3K		217
Sandanska Bistritsa Cascade	0.2					108	
Popina Laka HPP	—	1969	540	4.8	2P	21.5	71
Lilyanovo HPP	—	1969	372	6.7	2P	20	70
Sandanski HPP	—	1969	236	7.2	2P	14.2	48
Pirinska Bistritsa Cascade	0.1						
Pirin HPP	—		468	5.7	2P	21	70
Spanchevo HPP	—		415	7.8	2P	28	95
Dospat-Vacha Cascade	652						
Teshel HPP		1972	315	26	2F	60	166
Devin HPP		1984	138	72	2F	80	120
Antonivanovtsi Pumped-Storage HPP		1975	111.8	168	4F	160/40	245/58*
Krichim HPP		1972	162	61	2F	80	198
Vacha-New HPP		1972	82	9.2	2F	7	21.3
Vacha-Old HPP		1934	83.2	20	4F	14	21.6
Belmeken-Sestrimo Cascade	141.5						
Belmeken-Sestrimo Pumped-Storage HPP		1974	690	62.5	5P	375/380	556/220*
Sestrimo HPP		1974	534	56.6	2P	240	421
Momina Klisoura HPP		1974	251	56.6	2F	120	204
Chaira Pumped Storage Plant		1995-99	640/660	144/118	4	864/760	1200

* electric power generated by pumped storage hydro-power plant

** P = Pelton, F = Francis, K = Kaplan

ARDA Hydro-Power Cascade
commissioned 1956-1965



Kardjali HPP

Studen Kladenets Dam

Studen Kladenets HPP
Machine Hall

Ivailovgrad Dam
with hydro-power plant

Table 7 presents the development of the installed capacity in the Bulgarian power plants during the period reviewed here.

Table 7: Installed capacity of power plants in Bulgaria 1944-1970 in MW

Year	Total installed capacity	Electrification administration				Industrial plants
		Total	TPP	HPP	DPP	
1944	130.5	130.5	66.7	46.5	17.3	—
1945	126.7	126.7	66.7	46.5	13.5	—
1950	175.7	175.7	96.5	65.3	13.9	—
1955	482.1	390.3	223.6	133.4	33.3	41.8
1960	925.5	874.3	380.4	475.7	36.4	51.2
1965	2 127.5	1 913.3	111.4	768.4	33.5	214.2
1970	4 083.5	3 456.8	2 614.7	811.7	30.4	626.7

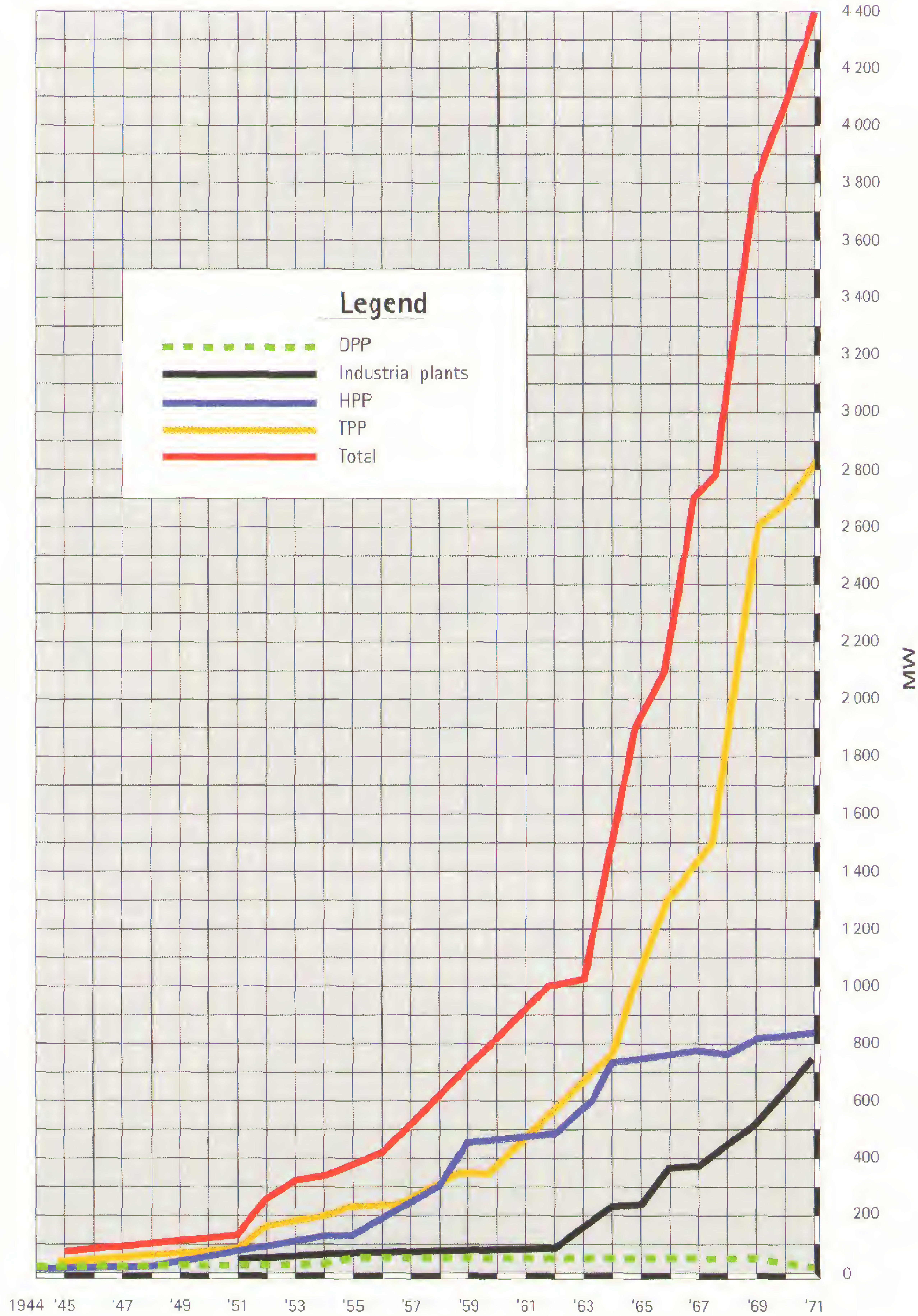


Fig. 9: Development of the installed capacities of thermal, hydro- and diesel power plants and industrial power plants, 1944–1971

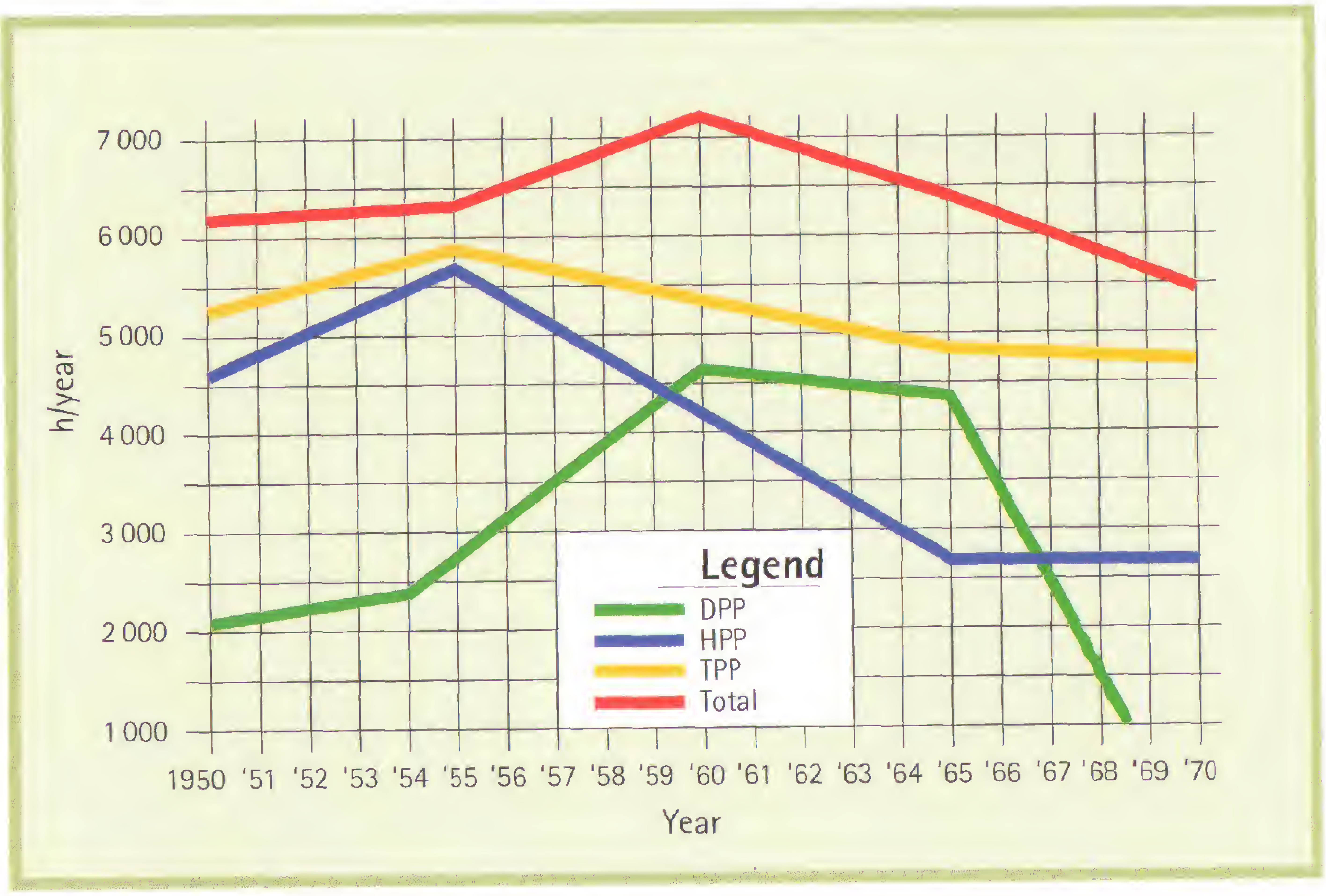


Fig. 10: Annual utilization ratio of the electrification authority power plants

These figures show that for a period of 25 years the total installed capacity of the power plants had increased 32 times which was really a quite rapid development. Electric power generation developed at the same rate, thermal power plants contributing the largest share of it– 63% in 1950 and 72.6% in 1970. At the same time the share of industrial power plants considerably increased and at the end of the period it reached 16.2% of the power generated (Table 8).

Table 8: Electric power generated in Bulgaria, kWh x10^6

Year	Electrification Administration				Industrial plants	Total
	TPP	HPP	DPP	Total		
1950	505.9	267.5	23.6	797.0	—	797
1955	1 258.1	644.0	38.5	1 940.6	132.4	2 073
1960	2 441.8	1 883.9	167.8	4 493.5	163.5	4 657
1965	6 754.0	1 998.6	148.0	8 900.6	1 347.4	10 248
1970	14 177.0	2 152.2	10.8	16 340.0	3 174.8	19 515

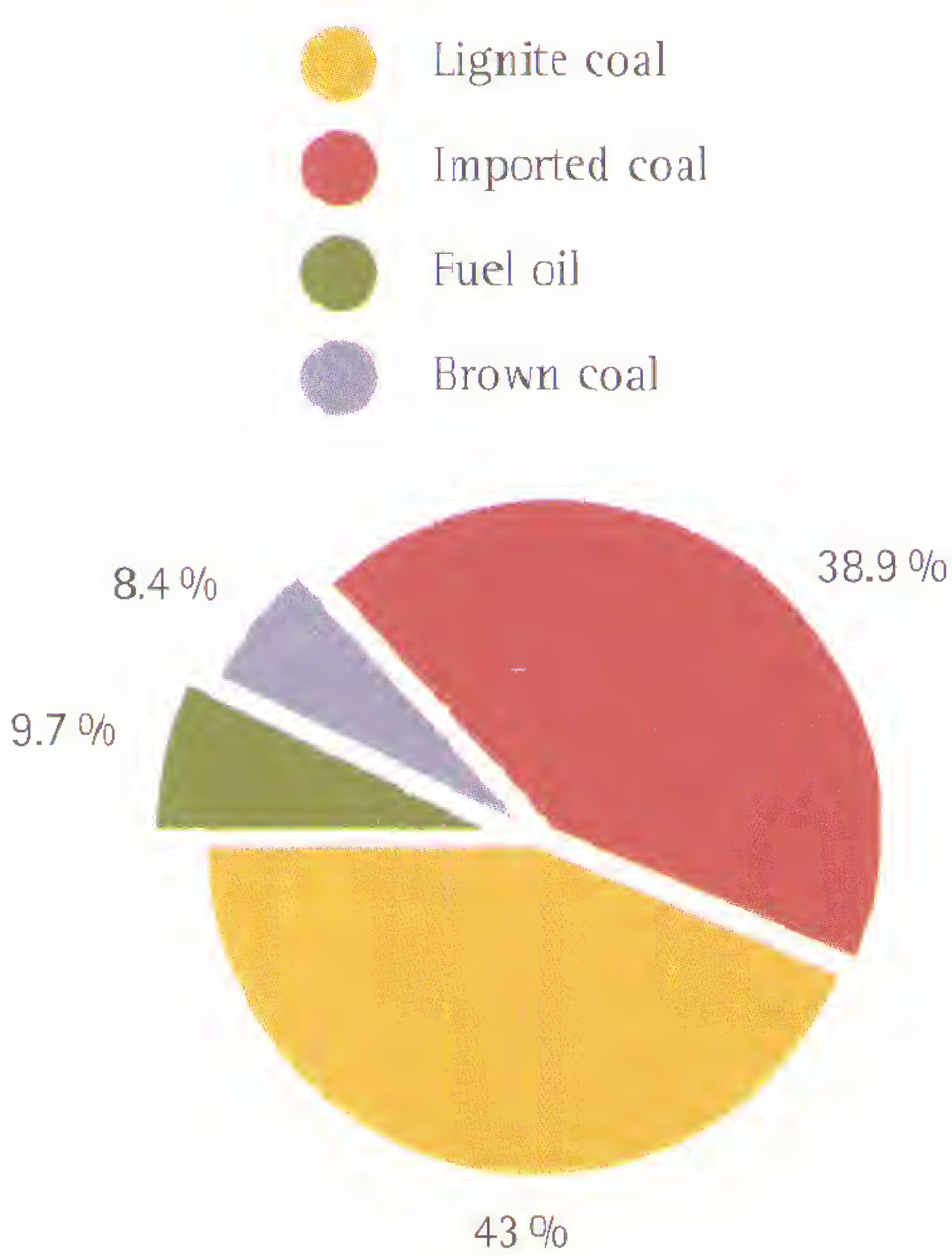


Fig. 11:
Power plants of the electrification authority (not including industrial power plants) grouped by type of fuel

The annual utilization ratio of the plants belonging to the electrification administration in the period 1950-1970 tended to decrease, its highest value was T = 5870 h in 1955, while for TPP that utilization ratio reached 7209 h (1960) which was a very high value.

The auxiliary electricity consumption of the power plants grew over the years and its highest value reached 10.94 % in 1969. At the thermal power plants alone it reached 12.79%, as for the hydro-power plants, it was 0.31 % of the power generated.

The specific fuel equivalent consumption for thermal power plants varied between 540 and 405 g fuel equivalent/kWh. In the reviewed period 1950-1970 the pay-roll staff employment ratio in the electrification authority power plants (not including industrial plants) was significantly reduced from 5.57 employees/MW in 1950 to 1.83 employees/MW in 1970. For the thermal power plants alone that ratio was 8.81 employees/MW and 2.06 employees/MW respectively.

All these technical and economic indices of electricity generation sources show their major improvement in the course of time.

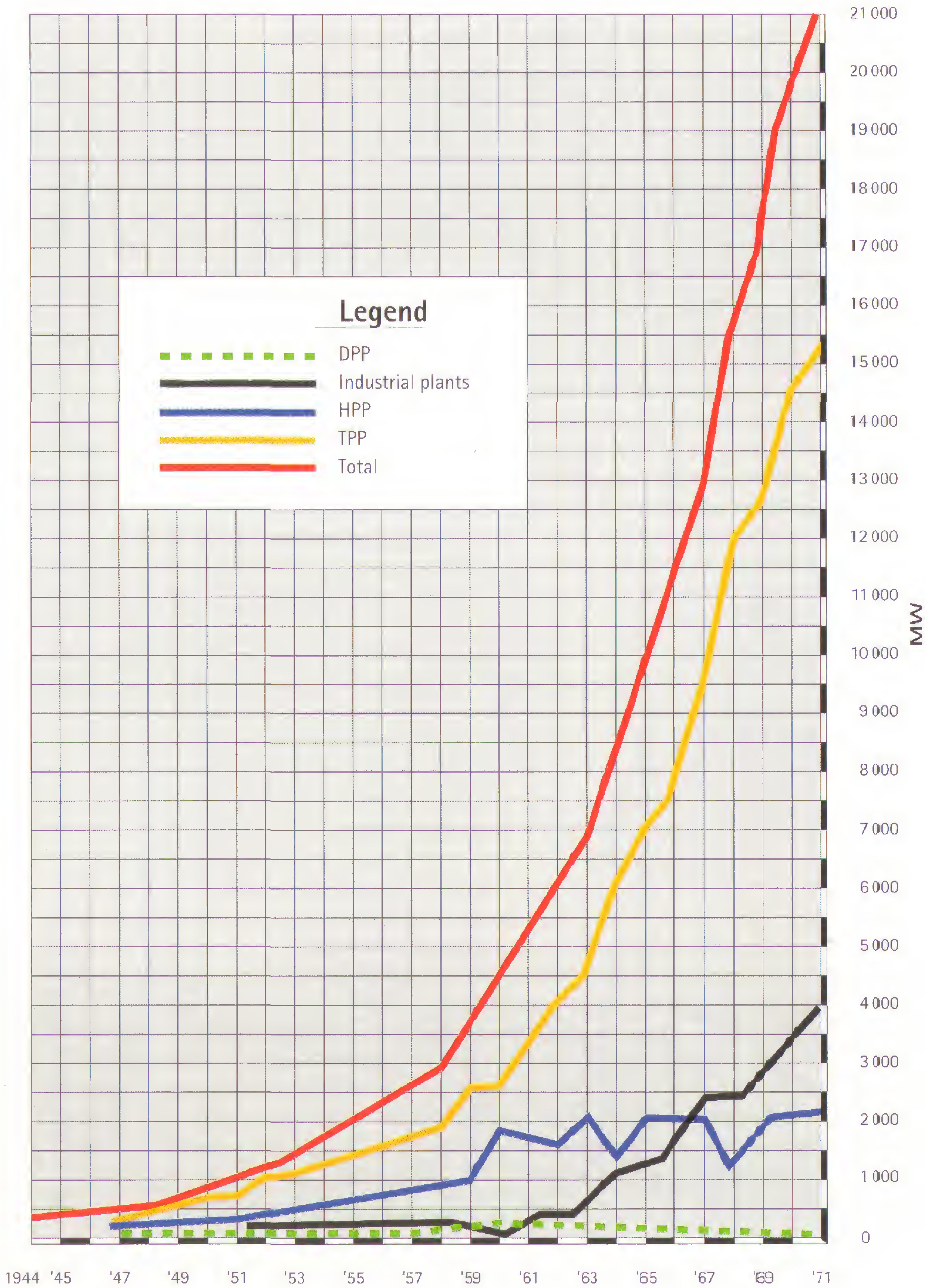


Fig. 12: Electric power generated in Bulgaria by power plant types in the period 1944–1971

Fig. 11 illustrates the allocation of the generated electric power among power plants of the electrification authority, without industrial plants, according to type of fuel. It shows that the local resources (lignite and brown coal) supported 51.4% of the electricity generated, while the other resources were imported.

3.2. Transmission and Distribution Networks

The overall electrification network of the country, including the electric power transmission system, developed on the basis of the General Conceptual Electrification Plan of 1941 and the Second General Plan of 1955 and its updates. Energoproject worked out separate general long-term plans (until 1980) for the distribution networks of the different electrification regions and towns (in a perspective until 1980).

Until the end of the 1950's the transmission system–overhead transmission lines (OHTL) and transformer substations, was developed for 110 kV voltage. The 110 kV overhead transmission lines ring was completed in 1958. The 220 kV transmission voltage was introduced in 1959 through the transmission line from Aleko Substation to Gorna Oryahovitsa Substation. Similar to the 110 kV system, the "closed-loop" pattern was adopted. It was mainly the 220 kV transmission system that developed during the reviewed period.

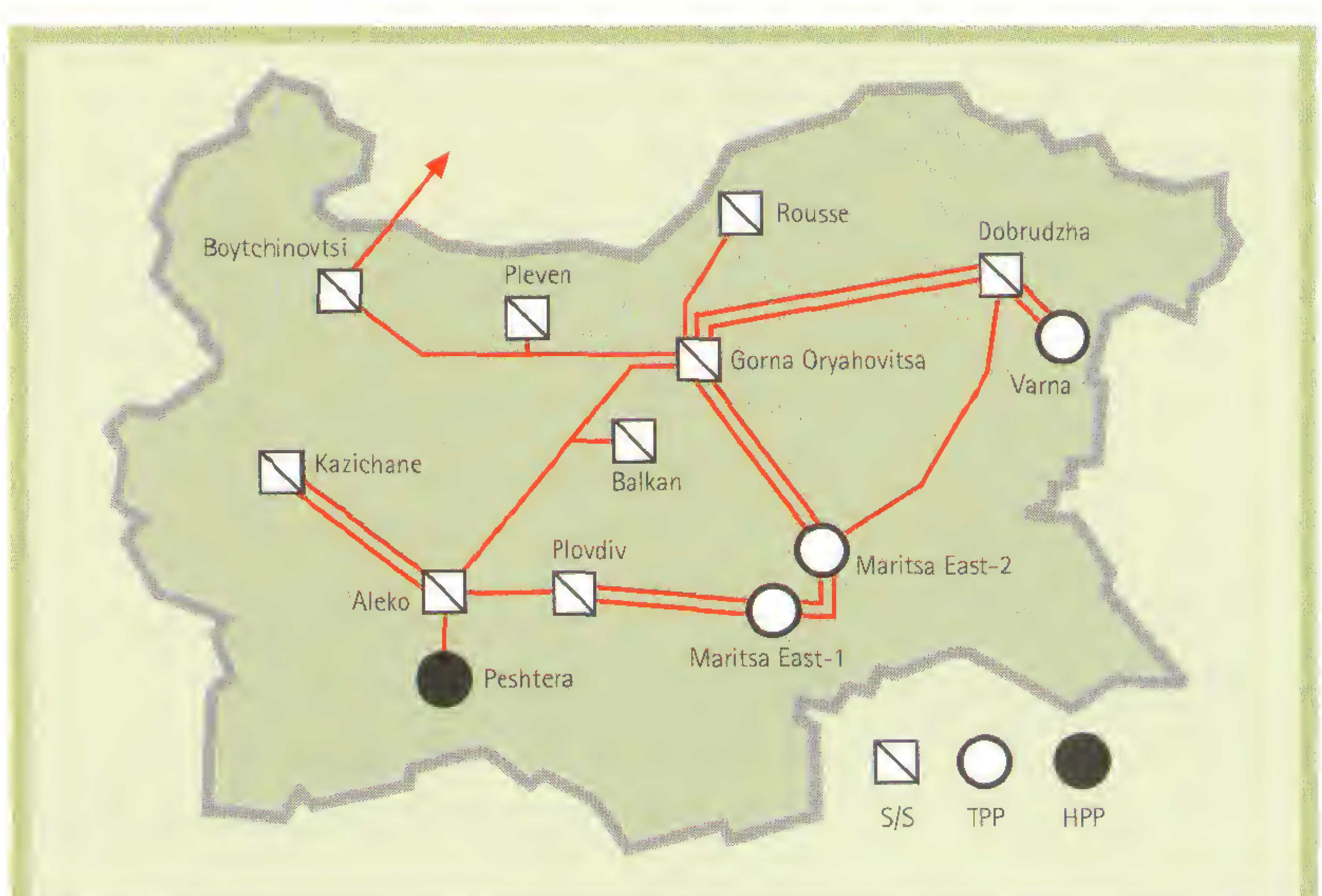
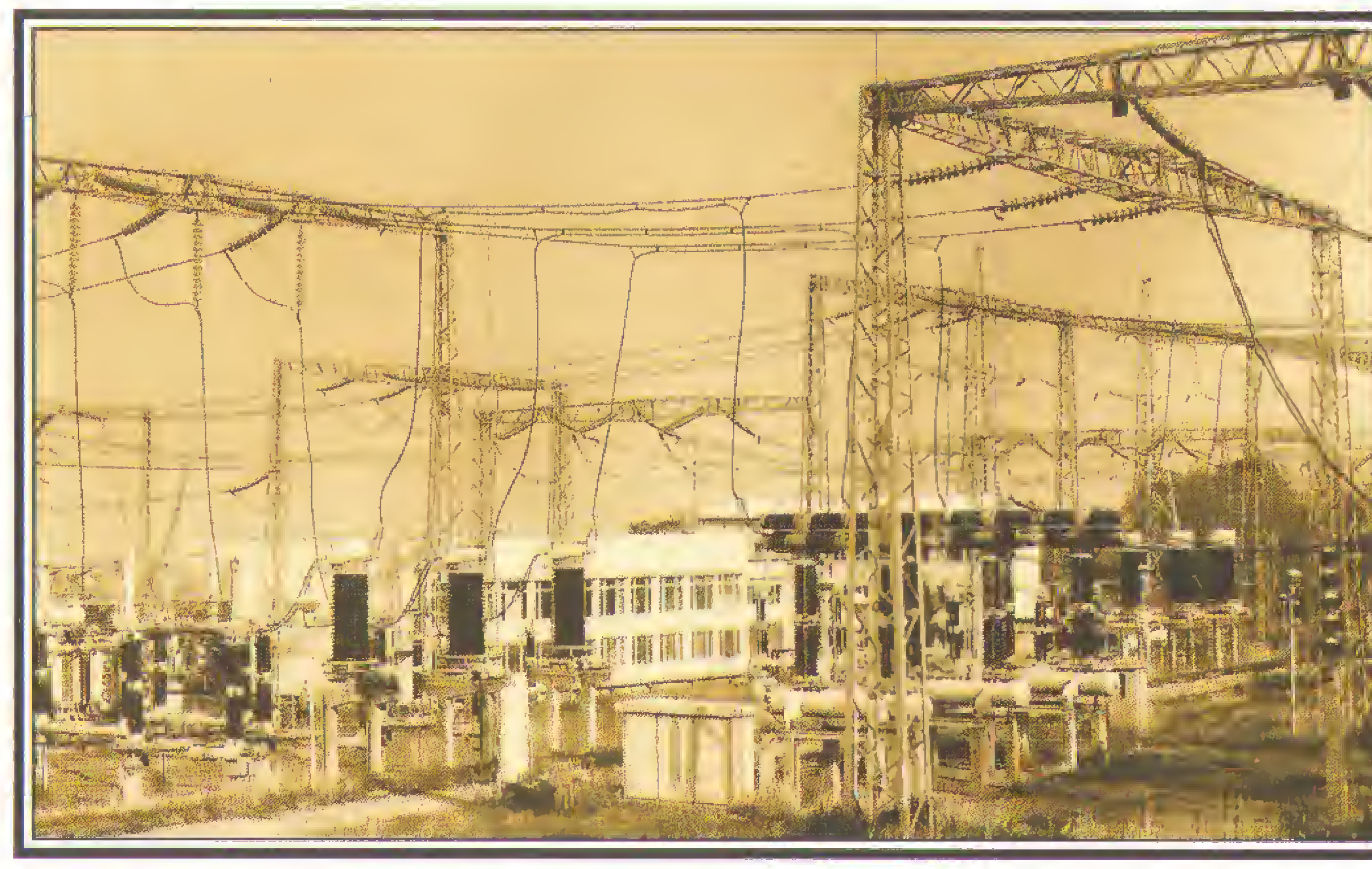


Fig. 13: Scheme of the 220 kV transmission system by the end of 1971

Initially, the 110 kV overhead transmission lines were supported by vibrated concrete poles and reinforced concrete cross arms on them. Reinforced-concrete structures were also used in the 110/20 kV substations with outdoor 110 kV switchyards. Soon after that, however, that practice was abandoned and both the poles and the substations intended for such a voltage were replaced by steel lattice towers for the overhead transmission lines and steel lattice structures for the substations.



220/110 kV Sofia South Substation

commissioned in 1975

Steel lattice structures are generally used for 220 kV overhead transmission lines and for 220 kV and 110 kV outdoor switchyards of the 220/110 kV substations. On the basis of statistical laboratory tests, Energoproject developed up-to-date designs of suspension and tension towers for that voltage.

Initially the 110 kV transmission lines used copper conductors (M-95 and M-120 mm^2), but later (until 1965) aluminium conductors steel reinforced (ACSR) again with small cross-section were used (AC-95, 120 and 185 mm^2). From 1965 on only two standard types of ACSR conductors were adopted–ACO-400 mm^2 and AC-185 mm^2. Standard designs were developed for steel-lattice towers for single and double circuits with conductors AC-150, 185, 240 and 300 mm^2 which were used until 1974.

The single circuit tower horizontal configuration initially adopted in the 220 kV overhead transmission lines were replaced by guyed portal towers. Later on, the first 400 kV overhead transmission lines were built with similar types of towers.

Further on, bolt type steel lattice towers for single and double circuits were applied.

An important point in the overhead transmission lines construction was the effort to use double circuit lines with a view to cutting down the time and volume of construction works, as well as to protect agricultural lands.

By 1970 the following substations were built:

- Nine 220 kV substations–3020 MVA installed capacity;
- One hundred and thirty 110/10-20 kV substations–5213 MVA installed capacity.

The 110 kV system had 110/20 distribution substations (also 110/10 kV in some of the larger towns) with two on-load tap changers. The first substations of that type designed and constructed by Bulgarian engineers were equipped with imported low-oil and air-blast circuit breakers until 1951. From that year on Bulgarian low-oil circuit breakers and disconnectors were applied. The 5.6 MVA transformer capacities used initially were gradually replaced by 20, 40 and 63 MVA, the last two–with tapped windings. Most of the 110 kV power transformers were made in Bulgaria. The substations had a double-bus system at the 10-20 kV side. The 220/110 kV substations were built with single-bus or double-bus systems, the unit power of their transformers reaching 200 MVA. Their transformers were also on-load regulated. After 1973–1974 glass insulators were used in all substations and transmission lines.

For the medium-voltage networks in 1954 started the production of hollow centrifugal 12-meter poles types "300" and "500" for single and double circuits for conductors M-25, M-35 and M-50. These poles replaced the vibrated-concrete poles cast on site, used till that time. Later on, 13-meter poles were introduced. With the application of aluminium-steel conductors, new reinforced-concrete and steel-lattice towers were developed for single and double circuits for conductors–AC-50, AC-70, and AC-95 mm^2.

With the nationalization of electrification, the green light was also given to rural electrification which was underdeveloped during the first half of the 20th century.

For the purpose, a specialized Regional Electrical Projects Directorate was established with Energohydroproject with 12 branch offices in the country for the respective electrification regions and one department "Urban Electrical Networks" for Sofia and for the general electricity supply plans for all towns and holiday resorts in the country (1952).

The Regional Electrical Projects Directorate set all the designs of town and regional electrical networks on a scientific basis, by developing and applying new and appropriate methods and guidelines. The constant growth of electrical loads reaching 10 MW/km^2, and even 20 MW/km^2 in perspective, necessitated "deep" HV penetration in the large cities through 110 kV transmission lines for 110/10–20 kV substations. The large industrial works also adopted 110 kV power supply.

The development of the electrification system in Bulgaria necessitated the construction of an interconnection line with Romania at the very beginning of the period reviewed here. For the purpose, a 60 kV underground cable line Rousse–Giurgiu was laid across the Danube in 1950.

In addition, two 110 kV interconnections with Yugoslavia were built: Breznik Substation–Varla HPP (1961), and Kula Substation–Vrashka Chuka Substation (1964). At the same time, in 1960 the East-European countries Hungary, East Germany, Poland and Czechoslovakia signed an agreement for interconnecting their power systems for a parallel operation (1960).

From 1962 on the East-European countries-members of the COMECON, including Bulgaria, established the Interconnected Power System for parallel operation and coordination of the planned-mode on-line control between the different dispatching centers. In 1967, a 220 kV interconnection line with Romania-Boichinovtsi-Kraiova was commissioned. Later on it was redirected to connect the Kozloduy nuclear power plant and Kraiova. By the end of the period reviewed here, the electric power supply provided by the electric power systems of the Interconnected Power System reached 13 billion kWh (1970).

Table 9 presents a summary of the overall electric power network development in Bulgaria within the period reviewed here.

Table 9: Length of the electric power network (km)

Year	750 kV	400 kV	220 kV	110 kV			Medium Voltage			Low Voltage		
	OHTL			OHTL	Cable	Total	OHTL	Cable	Total **	OHTL	Cable	Total **
1948	—	—	—	—	—	602*	9062	—	9 062	14 605		14 605
1950	—	—	—	396		1 146*	12 127	—	12 127	19 286		19 286
1955	—	—		1 134		2 088*	17 825	—	17 825	24 833		24 833
1960	—	—	329	2 442		3 447*	25 087	—	25 087	35 143		35 143
1965	—	—	821	3 655		4 758*	29 734	—	29 734	40 881	1 576	42 457
1970			1741	4 975		5 493	33 489	3 157	36 646	44 780	3 894	48 674

* including 60 kV and 35 kV networks

** for the period 1948–1960, including a minor length of cable lines

Thus, for a period of 22 years the 35–220 kV overhead transmission lines increased 12 fold, the medium voltage networks–4 fold, and the low-voltage networks–3,3 fold which indices show a rapid development of electrification in Bulgaria.

With respect to the relay protection used, it should be noted that 3-zone distance protections were used against all kinds of short circuits in the 110 kV networks, and three-stage directional earth fault protections–as backup. Short overhead transmission lines used mainly differential protections. Three-phase automatic reclosing (ARC) was applied. The busbar differential protections were normally used at the 110 kV substations with single-section and double busbars.

In the 220 kV networks, the main protections were 3-zone distance protections, and the back-up ones were four-stage, directional earth fault protections. In some cases, differential protections with a cable connection, or differential-phase HF protections were applied. The automatic reclosing devices permitted application of single-phase or quick three-phase tripping. The busbars in the 220 kV substations were fitted with differential protections and circuit breaker failure backup.

Emergency automation was implemented by means of automatic frequency load shedding systems, automatic frequency isolation of power plants in an independent region, decentralized load shedding automatic devices in cases of transformer overloading, automatic dividing devices for short-circuit current limiting and automatic dividing devices for interconnection transmission line overloading and asynchronous operation.

The reactive electrical loads were compensated by low and medium voltage static capacitor banks.

3.3. Electricity Demand

During the period reviewed here, the electricity demand and the maximum load of the electrification system significantly increased as evident from Table 10.

Table 10: Gross electricity demand and maximum load of the electrification system

Year	Electric power			Maximum load, MW
	million kWh	Annual growth, %	kWh per capita	
1945	401	—	57.8	58
1950	819	15.4	112.6	113
1955	2 106	20.8	281	346
1960	4 685	17.3	596	808
1965	10 232	16.9	1 246	1 591
1970	19 407	13.7	2 286	3 295

There was a high annual rate of electricity consumption. In the sixties it grew 3–6 times faster than the national income.

Table 11 presents the structure of electricity consumption. It shows that the industry occupied the largest share of it–49.7÷58.8%, and the share of public service demand constituted 24.7% of the gross electricity consumption and that percent rate gradually decreased reaching 17.4% in 1970.

Table 11: Electricity consumption by consumer categories (kWh x 10^6)

Year	Industry	Transport & Communi-cation	Agri-culture	Civil Cons-truction	Public Utility Sector		Auxiliary Consump-tion	Trans-mission Losses	Total Consump-tion
					Total	Household			
1952	686	2.1	7	4	341	135	114	206	1 379
1955	1 055	52	70	61	390	206	166	312	2 106
1960	2 491	96	164	74	906	530	317	637	4 685
1965	5 555	253	455	135	2 054	1 180	1 047	786	10 285
1970	11 550	404	691	272	3 405	2 595	1 636	1 448	19 616

That was mainly due to the increased share of industry, mainly due to the high energy-intensive character of metallurgical and chemical industries (Table 12).

Table 12: Relative electricity consumption by branches of industry (%)

Industry	1952	1955	1960	1965	1970
Heating	5	8.4	5.6	7.4	11.1
Metallurgy	10.6	18.3	22.2	25.6	25.9
Machine Building	12.8	10.6	13.1	9.6	9
Chemical Industry	24.1	20.4	20.3	27.2	26.6
Production of materials for civil works	10.6	9.2	8.8	7.1	6.3
Light and Food Processing Industry	29	28.4	22.8	14.9	13.5
Others	7.9	4.7	7.2	8.3	7.6
TOTAL in million kWh	686	1 055	2 491	5 555	10 735

The other economic branches, such as transport, communications, agriculture and construction, had a small share in electricity consumption. The Bulgarian railways electrification started in 1963 and all main railways were electrified during the years that followed.

It is worth noting that by the end of the period reviewed (1970) all settlements in the country had been electrified. 5298 population centers (93.9%), giving residence to 99.6% of the Bulgarian population, were electrified.

In terms of operation, at the beginning of the fifties a dispatching service was created. Over the years that followed, it developed at three levels: National Dispatching Center in Sofia, regional dispatching centers (Sofia, Plovdiv and Gorna Oryahovitsa), and district dispatching units at the electricity supply enterprises and their branches. An automatic dispatching service and a telecommunication system covered 35 of the most important sites. Automatic frequency control system and exchange capacity control system were modeled.

By 1970, with the overall electrification of the country, the daily load curve of the electrification system considerably changed by seasons and time of the day.

The ratio between maximum and minimum loads significantly increased. In December 1970 the average monthly load minimum was 48% of the maximum, and the average annual load was about 40%. That necessitated the construction of load-following power plants, including pumped-storage hydro power plants.

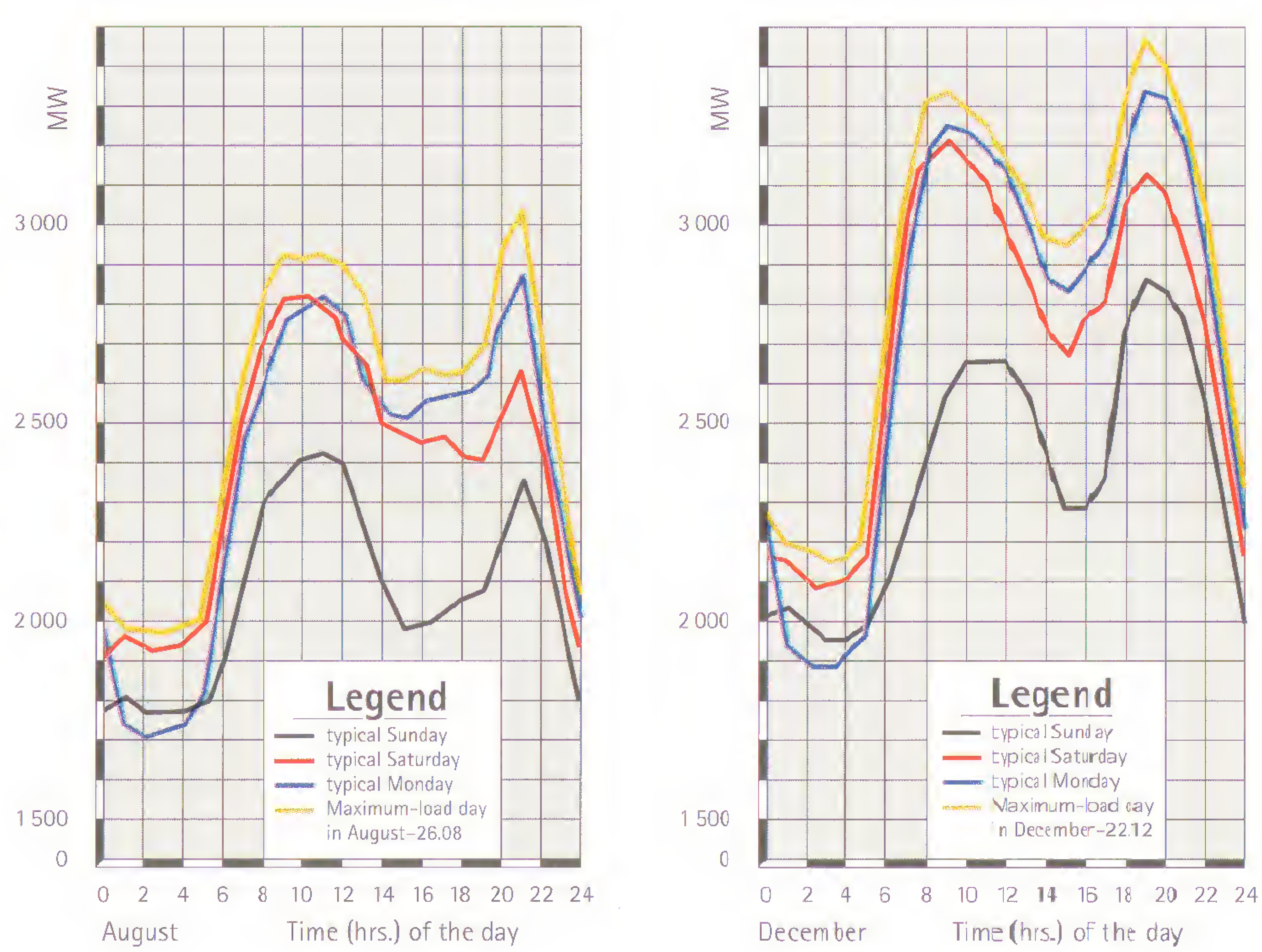
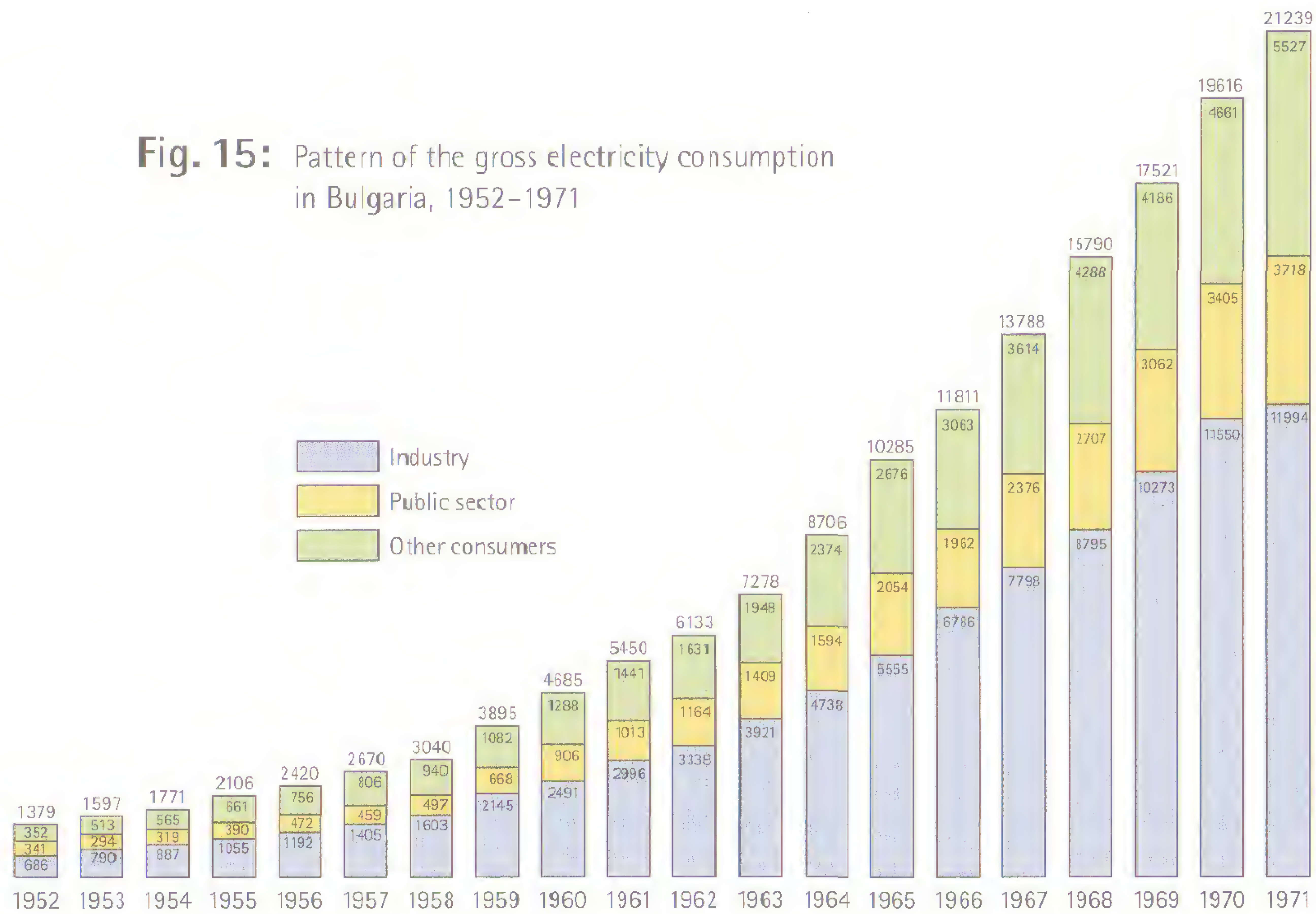


Fig. 14: Load curves on typical days in August and December 1971

Fig. 15: Pattern of the gross electricity consumption in Bulgaria, 1952–1971



During the reviewed period 1948–1970 the electrification in Bulgaria developed at a considerably high rate thanks to the following four main factors:

1. Nationalization of electrification.

2. Increasing the number of graduates of the State Technical University – engineers and architects of all specialties, as well as opening of technical schools for technicians training.

3. Faster development of national electrical industry in order to meet the requirements of the country and exports to other countries.

4. Establishment of Energoproject in 1948 – research institute of project investigations and engineering design. This institute became the center for training experts not only for the Bulgarian electrification, but for project engineering and construction abroad, as well. A number of other specialized research institutes also appeared in that field, closely connected with electrification, such as the Research and Design Institute of Electrical Industry, Techenergo.

4 Introduction of New Technologies in Electrification 1971-1991

The National Dispatching Center of Sofia

The 20-year period of developing an electric power system in Bulgaria (1971–1991) reviewed in this chapter was notable for the introduction of significant scientific and technological achievements in the three main sections of the electrification system: electric power generation, transmission and distribution.

Large public utility thermal power plants and district heating plants were constructed, as well as the nuclear power plant (NPP) at Kozloduy (Table 13).

Table 13: Public utility thermal power plants 1971–1991

Plant name	Year of commissi-oning	Installed capacity, MW			Fuel type
		1st stage	Extension	Total	
Bobov Dol	1973	210	2x210	630	brown coal
Maritsa East-3	1978	210	3x210	840	lignite coal

In parallel with the large thermal power plants, a number of smaller district heating plants were built in the larger cities (Plovdiv, Rousse, Pleven, etc.) Their capacity was usually several tens of megawatts with the exception of Plovdiv-North TPP (60 MW).

Bobov Dol TPP
commissioned in 1975
front view

The Belmeken Dam
constructed in 1974

In the field of hydro-electric power, after a number of project studies that started in the 1960's, the largest Bulgarian hydro-power cascades were constructed, as follows:

- Dospat–Vacha with total capacity of 401 MW (1972–1984);
- Belmeken–Sestrimo with total capacity of 1599 MW (1974–1995).

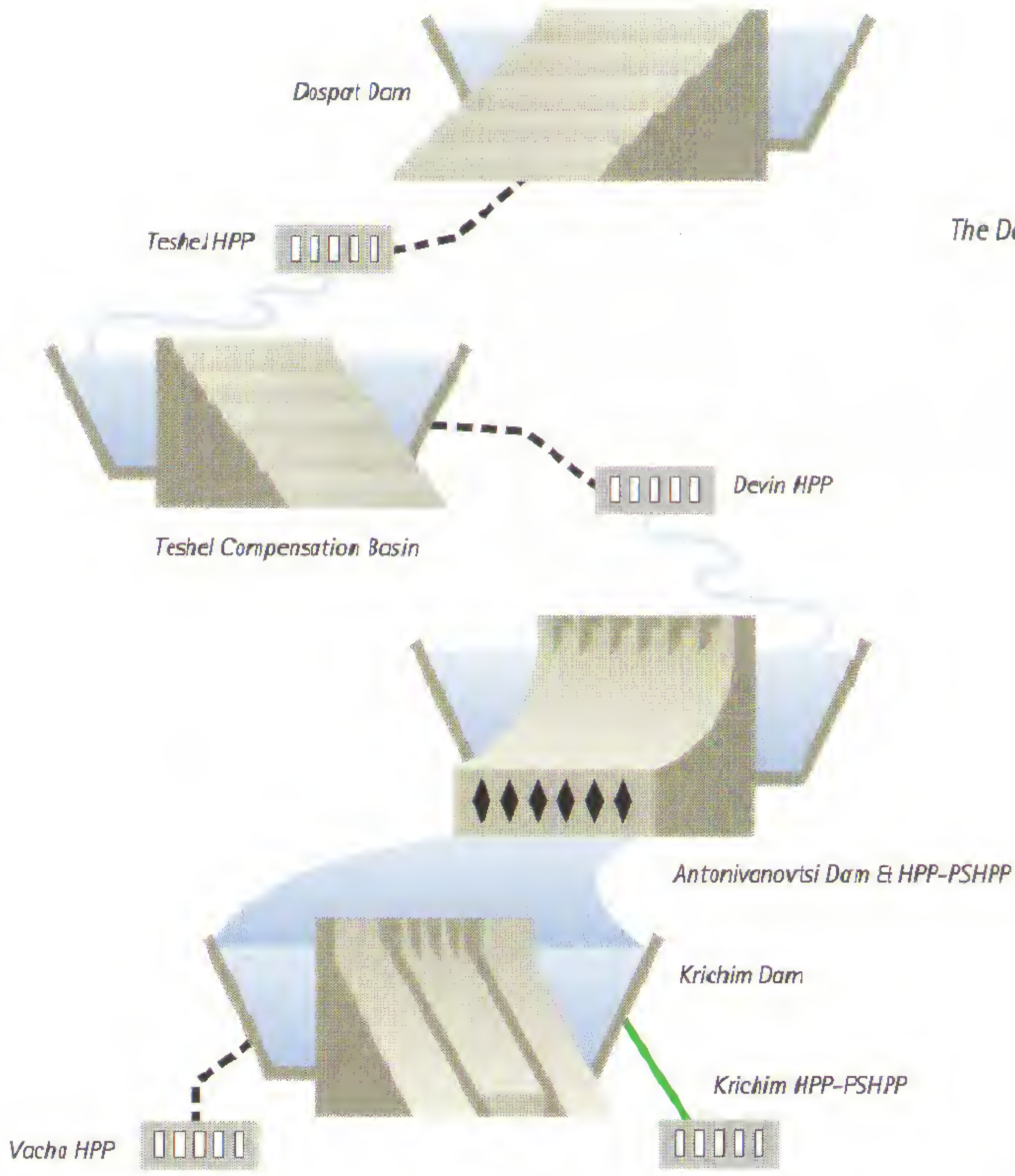
The Belmeken PSHPP
Machine Hall

Table 6 shows the main technical indices of the two hydro-electric cascades and the individual power plants attached to them, as well as the year of their commissioning. At two of these power plants there are pump-storage sets (Antonivanovtsi and Belmeken), while Chaira is a purely pumped-storage power plant of a very high capacity (864 MW, and 760 MW in the pumping mode).

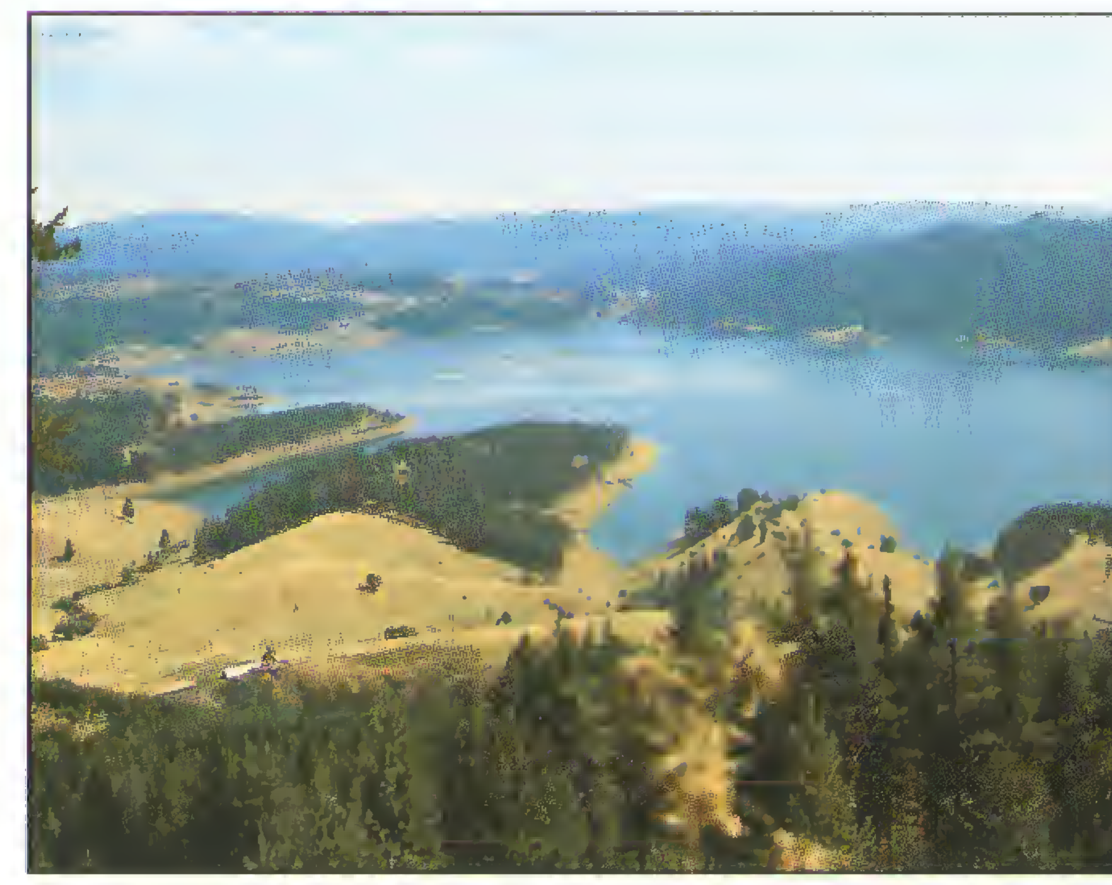
It is worth mentioning that the Chaira Pumped-Storage Power Plant is unique in terms of its installed capacity and other technical parameters, and is called the "Pearl" of the Bulgarian Hydro-Electric Engineering.

The two cascades together have been designed to generate 3211.10^6 kWh, and the overall annual utilization ratio of their installed capacities is relatively low (T=1600 h). Both cascades were built in the Rila–Rhodopes with numerous long headrace tunnels with covered culverts. It should be noted that many of the machines in these plants (pumps, generators), as well as the hydraulic facilities were products of Bulgarian industry.

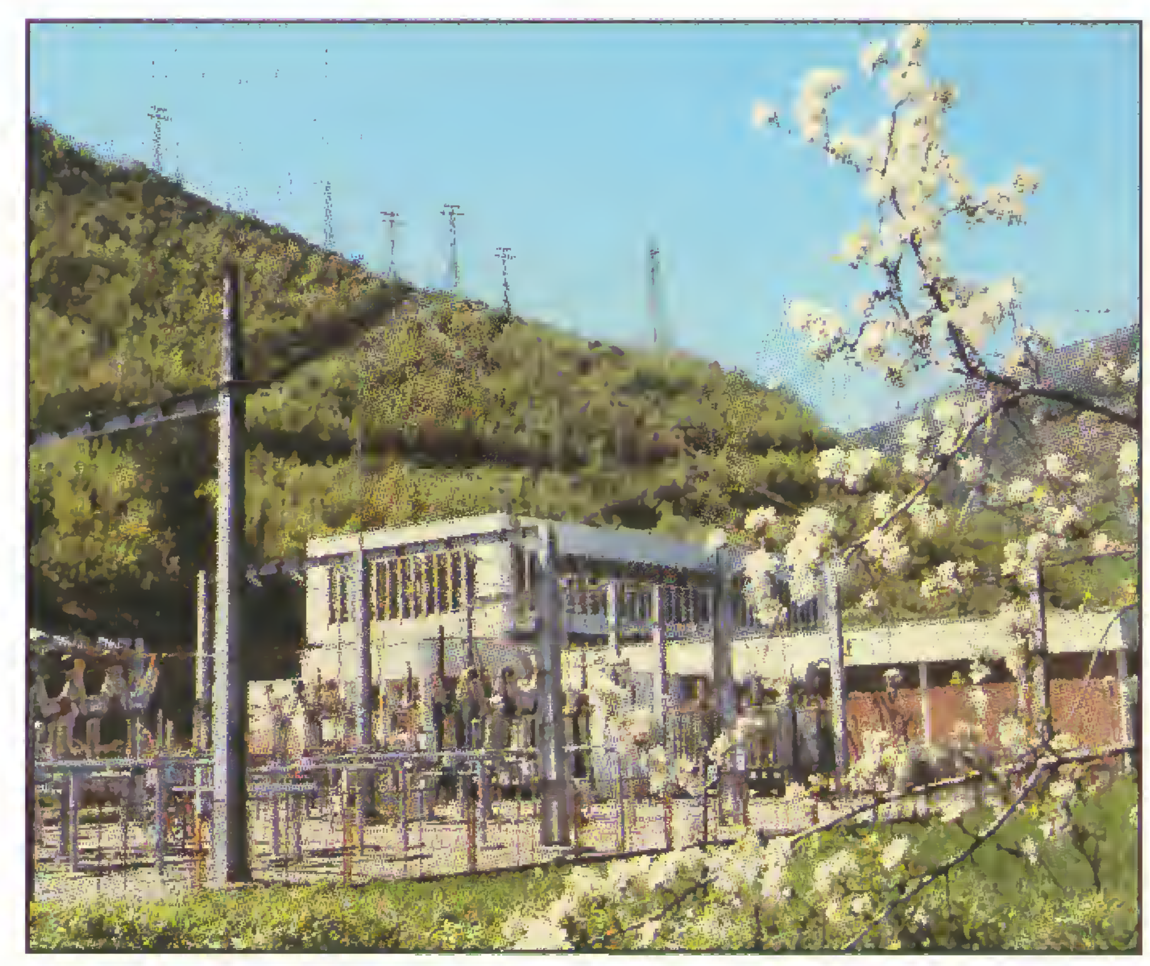
DOSPAT-VACHA Hydro-Power Cascade
commissioned between 1958 and 1965



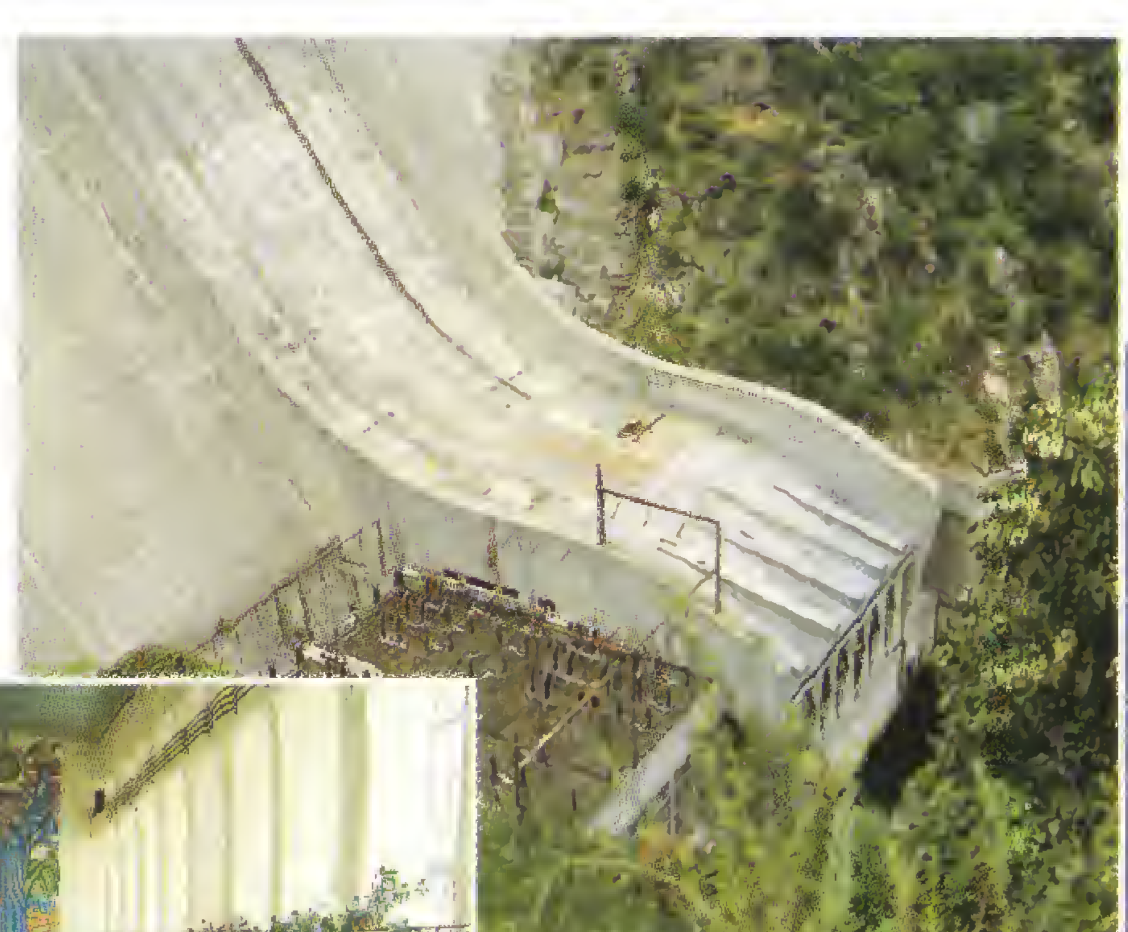
The Dospat Dam



Teshel HPP
Machine Hall



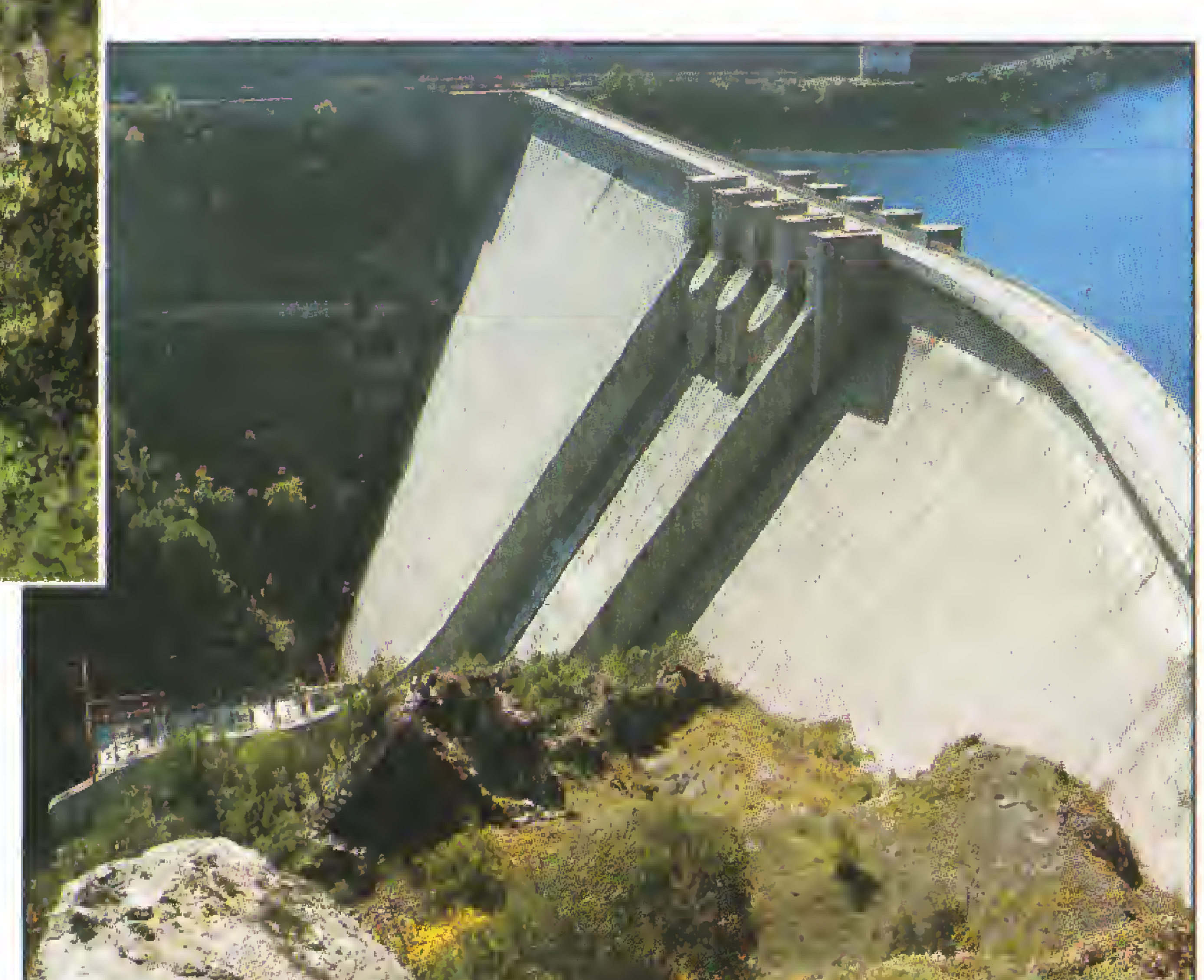
Devin HPP
general view



The Krichim Dam
spillway and
110 kV switchyard

Krichim (Antonivanovtsi)
Pumped-Storage PP
Machine Hall

Krichim (Antonivanovtsi) Dam



The Kozloduy NPP
commissioned in 1974 – 1991
overall view

The Kozloduy NPP
the 1000 MW unit machine hall

During this period the Kozloduy nuclear power plant was constructed and commissioned on the Danube (1974). Its initial capacity consisted of 2x440 MW VVER-440 reactors. Later on it was extended by another 2x440 MW reactors of the same type. In 1987 Unit 5, VVER-1000 with a capacity of 1000 MW was commissioned, and in 1991–Unit 6 of the same type. Thus the total capacity of Kozloduy amounted to 1760+2000=3760 MW. Its annual output is presented in Table 14.

During the period reviewed here, the electric power generated by Kozloduy NPP reached 35.6% of the total power generated in the country (1989), and in the recent years its share has exceeded 40%.

Table 14: Electric Power Generated by Kozloduy NPP, $kWh.10^6$

Year	Kozloduy NPP	Power Generated in the country	Share of the NPP %
1975	2 550	25 273	10.1
1980	6 165	34 833	17.7
1985	13 131	41 632	31.5
1988	16 030	45 021	35.6
1989	14 565	44 259	32.9
1990	14 655	42 130	34.8
1995	17 261	42 003	41.1
1996	18 082	42 801	42.2

The construction of a second nuclear power plant also was begun on the Danube–Belene NPP. However, after considerable progress of the construction, it was stopped and has not been continued.

The 220 kV overhead transmission line ring:
Aleko–Maritsa East–Dobrudja–Gorna Oryahovitsa–Aleko was completed in 1971.

During that period a 400 kV transmission network was constructed–comparatively big for the scale of Bulgaria. It was developed according to the "closed loop" pattern, like the 220 kV and 110 kV networks, and was completed in 1984. At the same time, interconnection lines for such voltages were also built with the countries listed below:

❖ Soviet Union (Moldova)	400 kV	(1972) and with Romania
❖ Soviet Union (the Ukraine)	750 kV	(1987) and with Romania
❖ Romania	400 kV	(1986) from Kozloduy NPP
❖ Turkey	400 kV	(1975)
❖ Greece	400 kV	(1988)
❖ Serbia	110 kV 400 kV	(1961, 1964) (1975)
❖ Macedonia	110 kV 400 kV	(1980) (planned for 1999)

The Kozloduy NPP
Control Room

110 kV substation
of the Petrochemical Plant–Bourgas

400/110 kV Bourgas Substation
the first Bulgarian substation of that type
commissioned in 1981

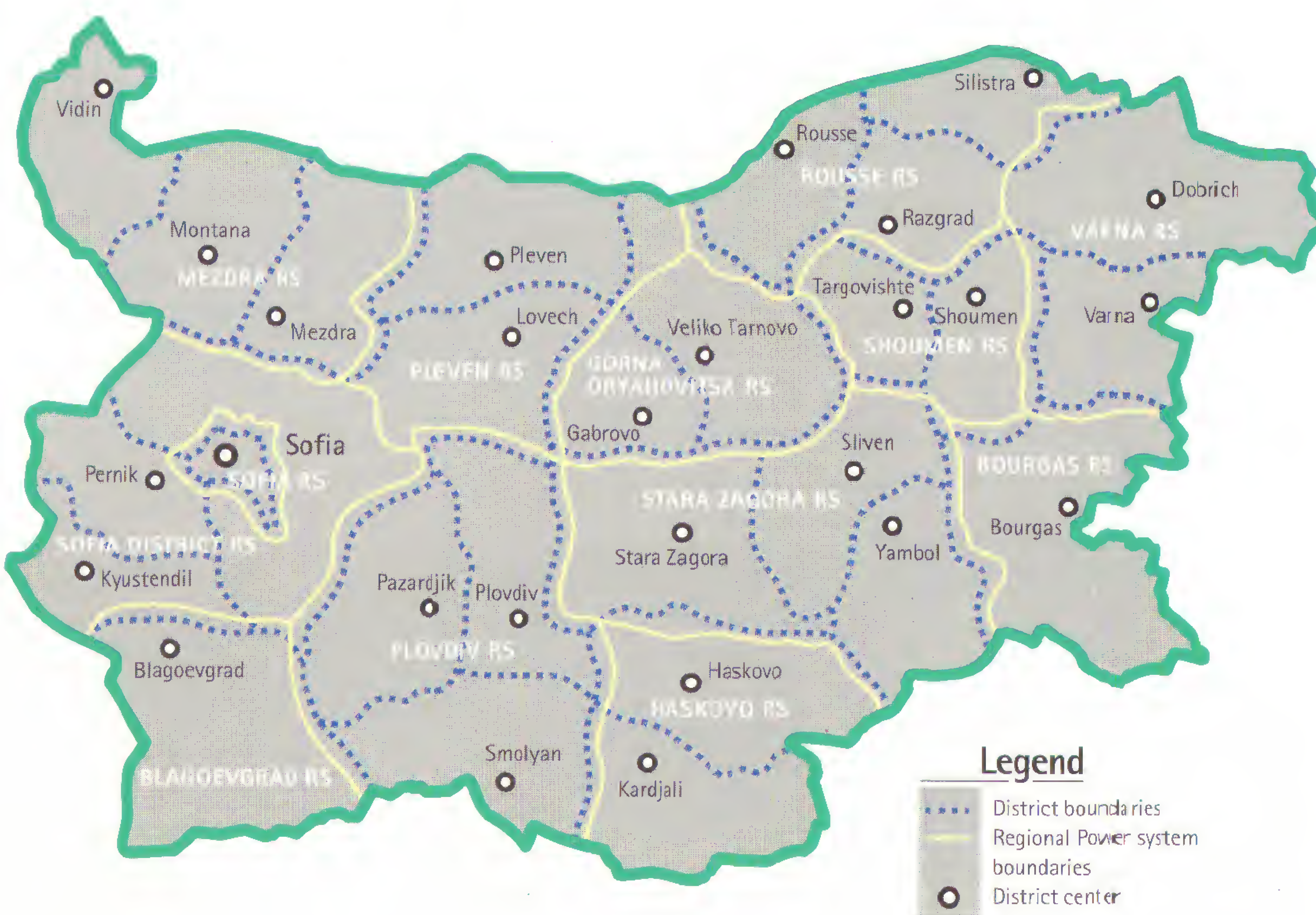


Fig. 16: District and boundaries of the regional power system in Bulgaria, 1968

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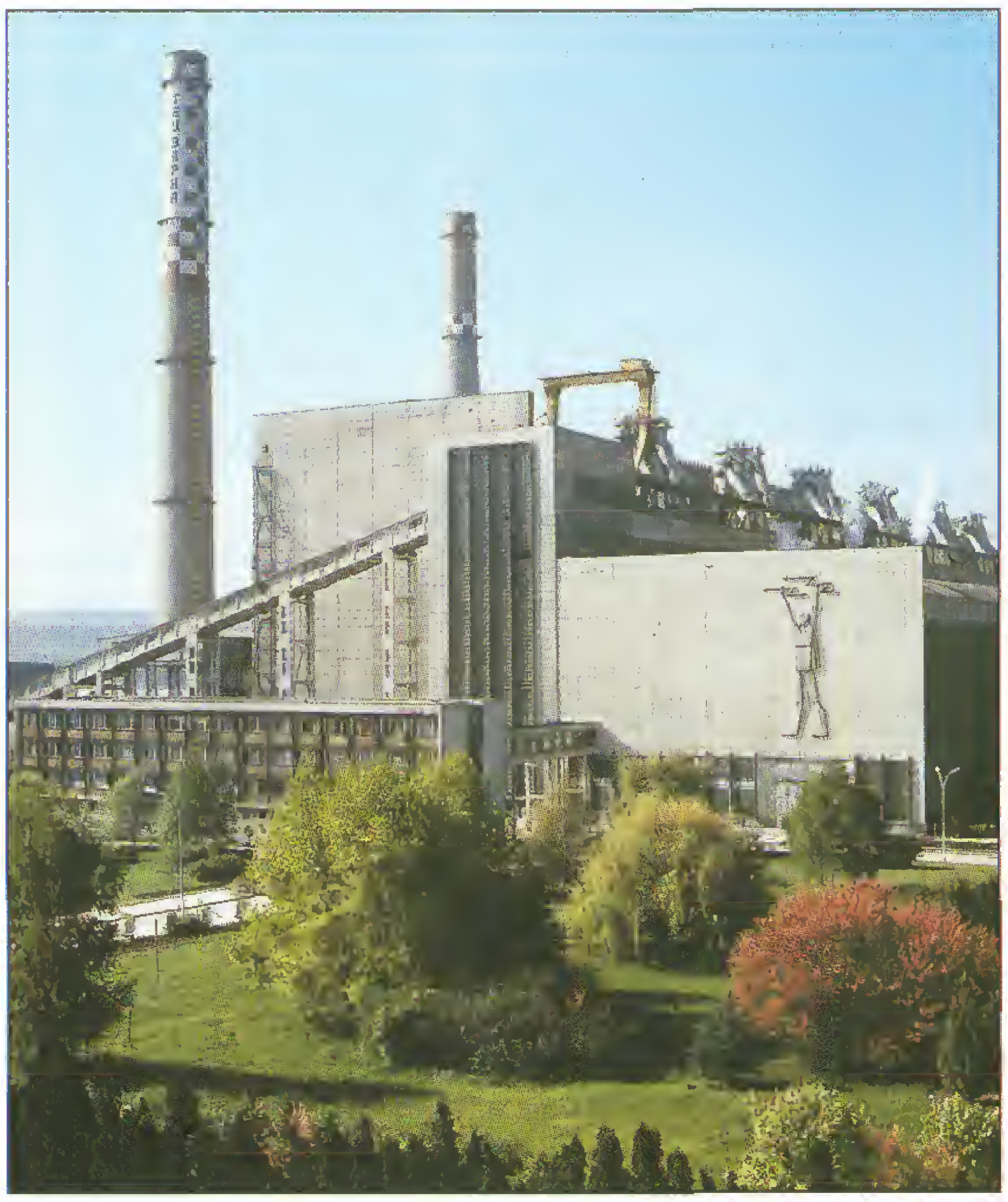


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2.


1. **Varna TPP**, *commissioned in 1969 – overall view*
2. **Varna Substation 750/400 kV**, *commissioned in 1987*
3. **Varna Substation 750/400 kV** *– transformer area*
4. **Varna Substation 750/400 kV** *– 750 kV switchyard*
5. **750 kV** *overhead transmission line to Varna Substation*

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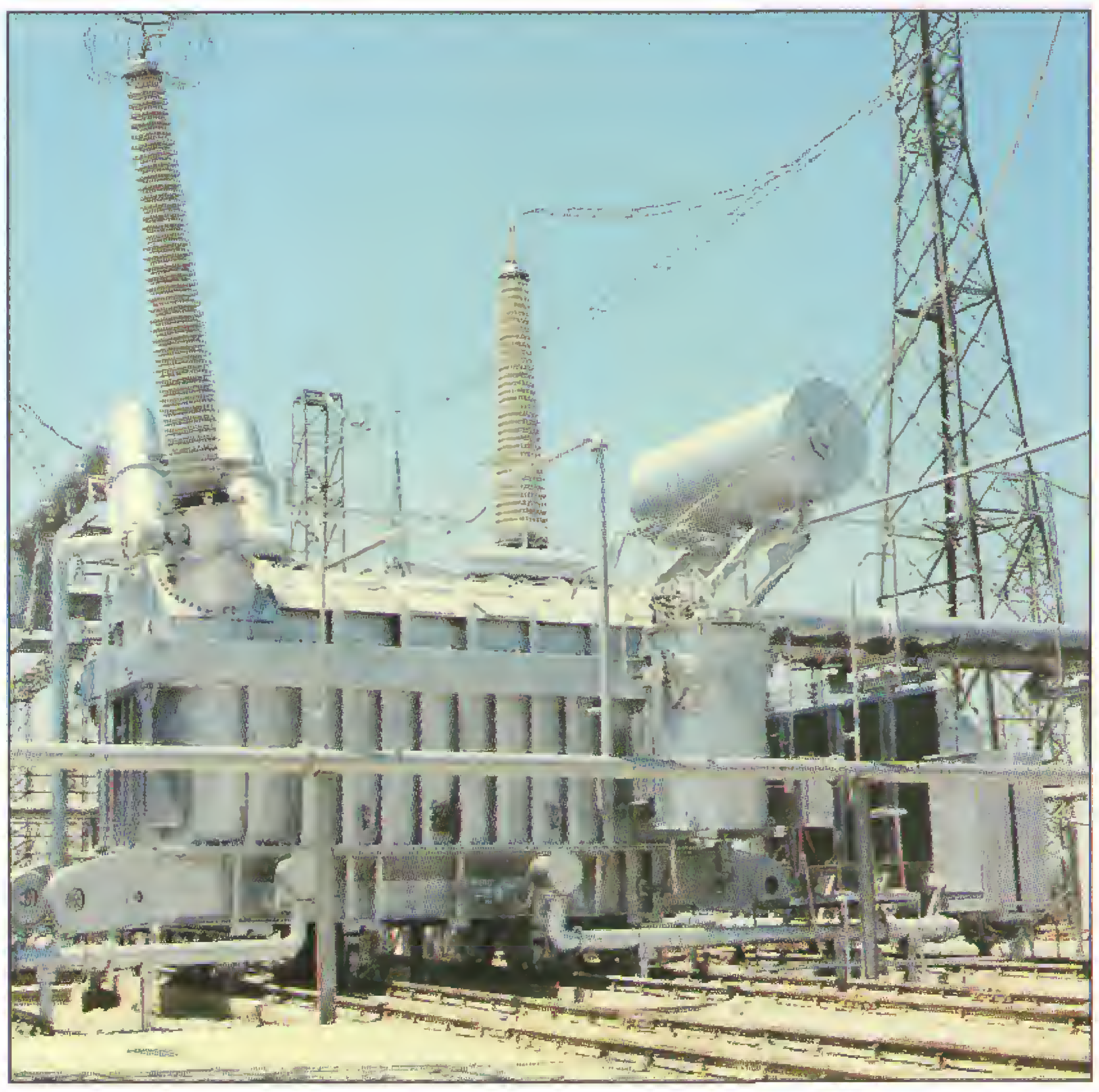



5.

The related power supply substations for 220, 400 and 750 kV were also constructed, as well as a considerable number of substations for 110/10-20 kV (Table 15).

Table 15: Number and capacities of substations and transformers (not including those at the plant sites)

Substations & transformers	Unit	1960	1965	1970	1975	1980	1985	1990	1997
S/s 750/400 kV	pcs.	—	—	—	—	—	—	1	1
Transf. 750/400 kV	MVA	—	—	—	—	—	—	2 500*	2 500*
S/s 400/220/110 kV	pcs.	—	—	—	2	3	3	3	3
Transf. 400/220 kV	MVA	—	—	—	1 260	1 890	1 890	1 890	1 890
Transf. 400/110 kV	MVA	—	—	—	250	500	1 000	1 000	1 000
Transf. 220/110 kV	MVA	—	—	—	800	1 000	1 400	1 400	1 400
S/s 400/110 kV	pcs.	—	—	—	—	1	3	5	7
Transf. 400/110 kV	MVA	—	—	—	—	500	1 500	2 500	2 900
S/s 220/110 kV	pcs.	2	4	9	11	13	14	18	18
Transf. 220/110 kV	MVA	800	1 600	3 020	4 420	5 200	5 660	6 860	6 860
S/s 110/10-20 kV	pcs.	52	86	130	186	283	406	442	451
Transf. 110/10-20kV	MVA	2 600	3 640	5 213	7 982	12 412	19 833	22 880	23 571

* two 1250 MVA banks (6 single-phase transformers)

110/10 kV Geo Milev Substation (Sofia)
with 100 kV SF_6 metal clad switchgear, commissioned in 1984

400/110 kV Sofia-West Substation
commissioned in 1981

400 kV overhead transmission line
steel lattice portal tower

400 kV overhead transmission line
double circuit lattice tower

220 kV overhead transmission line
guyed steel lattice towers

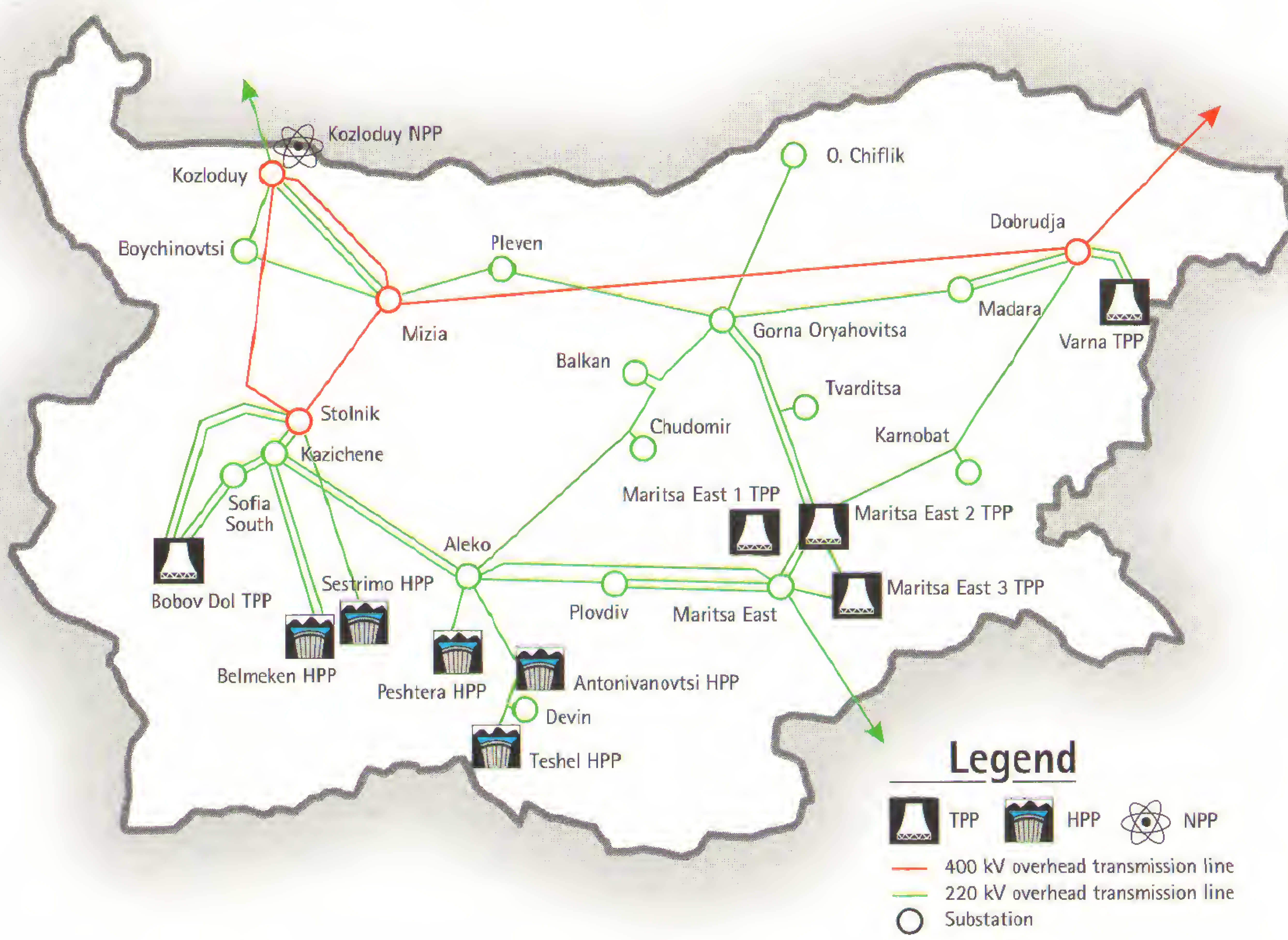
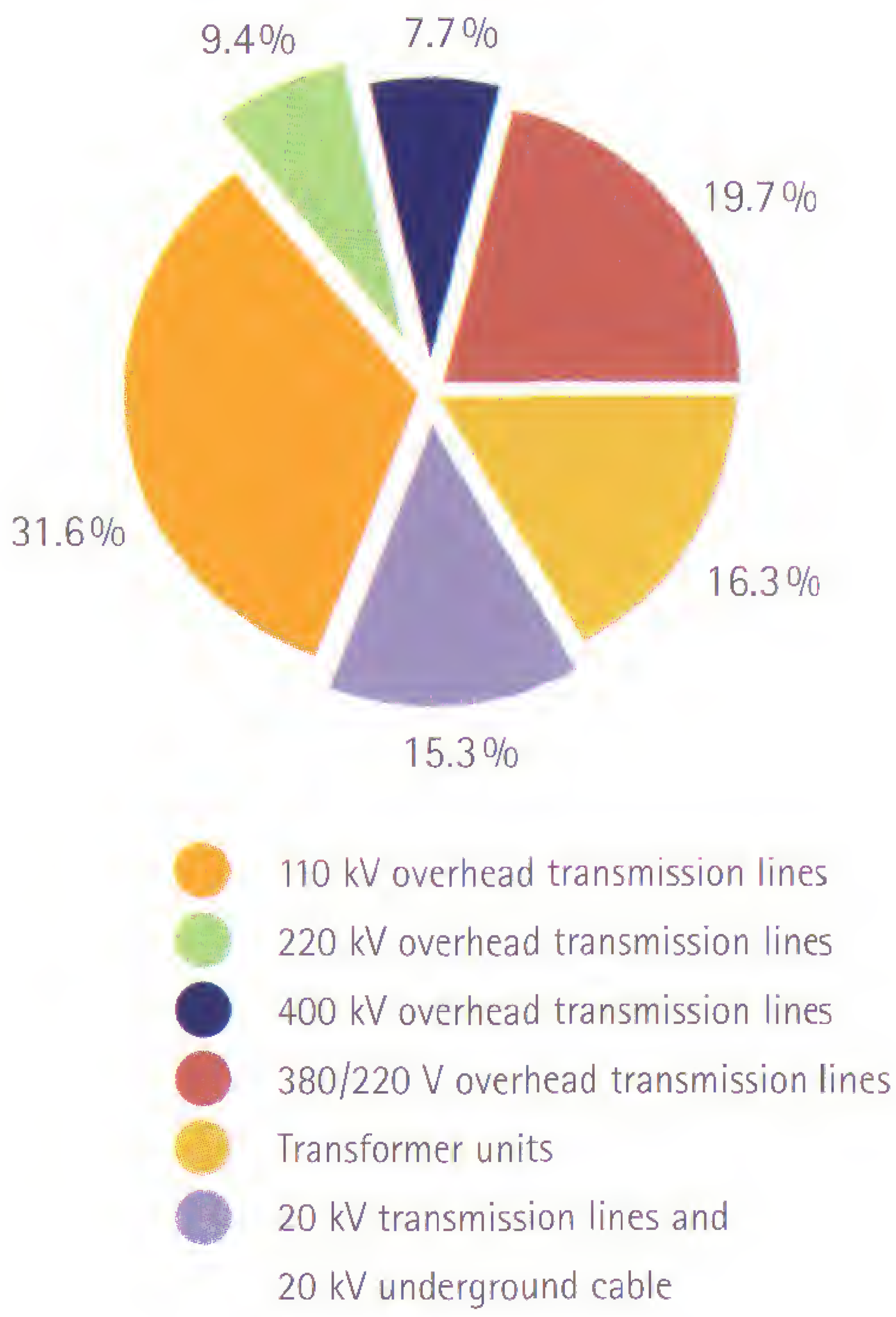


Fig. 17: Diagram of the 400 kV and 220 kV transmission system in Bulgaria, 1980

Fig. 18:
Electric power loses in transmission, transformation and distribution, 1980



During this period significant improvements were introduced in the primary and secondary switching technology of large 220, 400 and 750 kV supply substations. Up-to-date relay protection and automation were used.

High-voltage (110 kV) "deep penetration" was applied in the central regions of the large cities: Sofia, Plovdiv, Varna and Rousse, with a view to managing the larger electrical loads. For the purpose, 110 kV oil-filled cables were used, as well as dry cables with polyethylene insulation. 110/10-20 kV substations were built, with 110 kV metal-clad switchgears and SF_6 insulation.

The cables used in MV and LV distribution networks had polyethylene insulation and PVC insulation.

By means of the 220 kV, 400 kV and 750 kV interconnection lines Bulgaria joined the Interconnected Power System of the East European countries controlled by the Dispatching Center in Prague.

Table 16 presents the development of electricity demand by economic branches for the period 1970–1989.

Table 16: Development of electricity demand in various branches of the economy (1970–1989)

Branch/Year	Unit	1970	1975	1980	1985	1988	1989
Demand	mln. kWh	19 406	28 860	38 665	45 925	49 167	48 675
Industry	%	59.9	51.4	46.1	43.6	43.1	42.18
Civil construction	%	1.4	1.5	2.6	2.5	2.3	2.04
Transport & communications	%	2.1	2.8	2.9	2.9	3.0	3.10
Agriculture	%	3.5	3.3	2.8	2.4	2.2	2.41
Public utility sector	%	17.4	22.4	27.3	30.0	29.6	30.75
Households	%			17.7	20.8	20.2	20.92
Transmission	%	7.4	8.3	8.9	8.7	9.6	9.57
Auxiliary consumption	%	8.3	10.3	9.4	9.9	9.9	9.95

During the period reviewed here the share of industrial electricity demand decreased. This was due to the delayed construction of new energy-intensive industrial enterprises such as metallurgical and chemical works. On the other hand, the share of public service demand increased but was still low compared to that in the developed countries.

Fig. 19: Electricity supply system of Sofia (1978)
A. For the period until 2000,implemented 1985
B. A concept of transition from "main line" to "radial"-type network after 2000

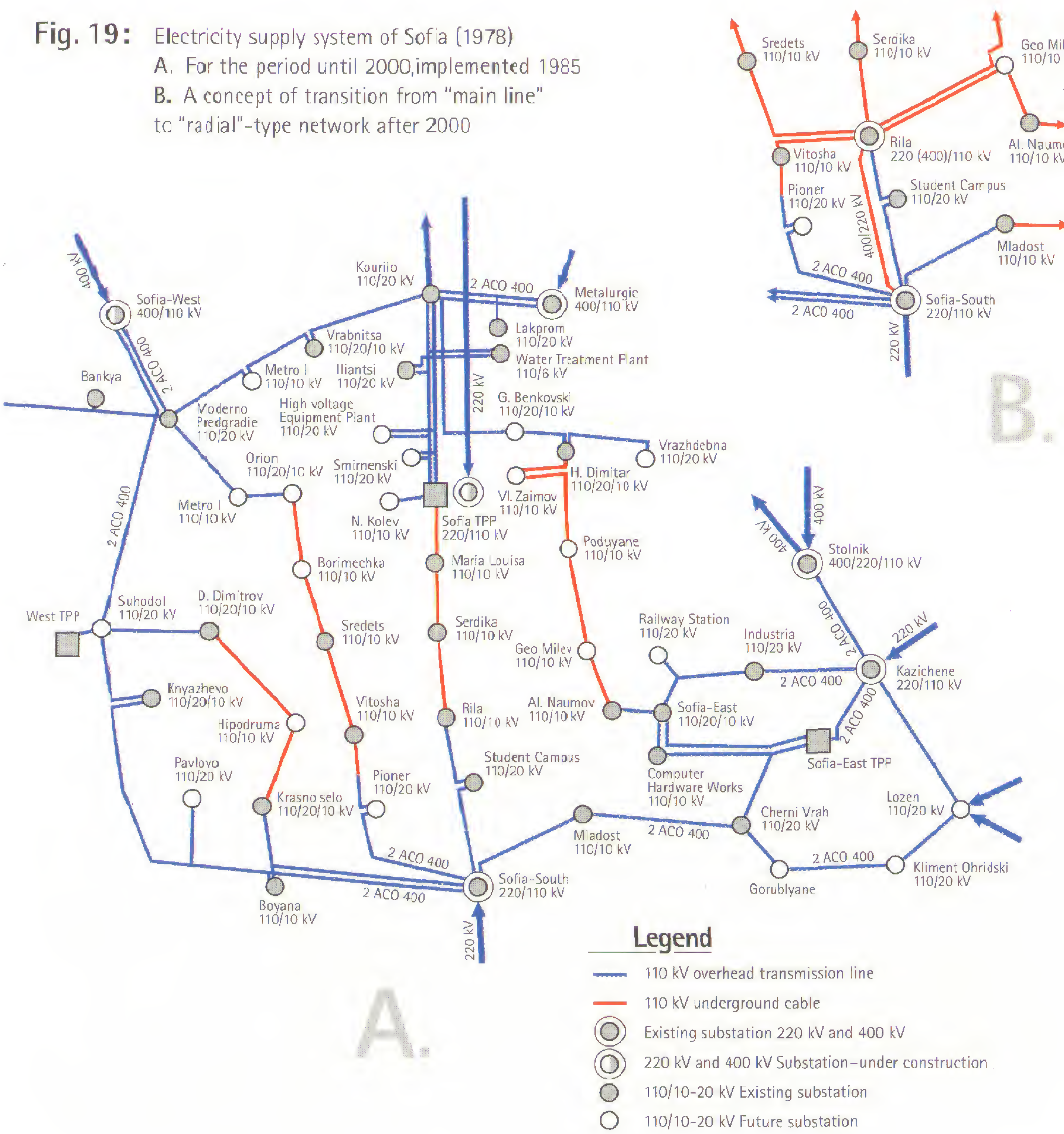
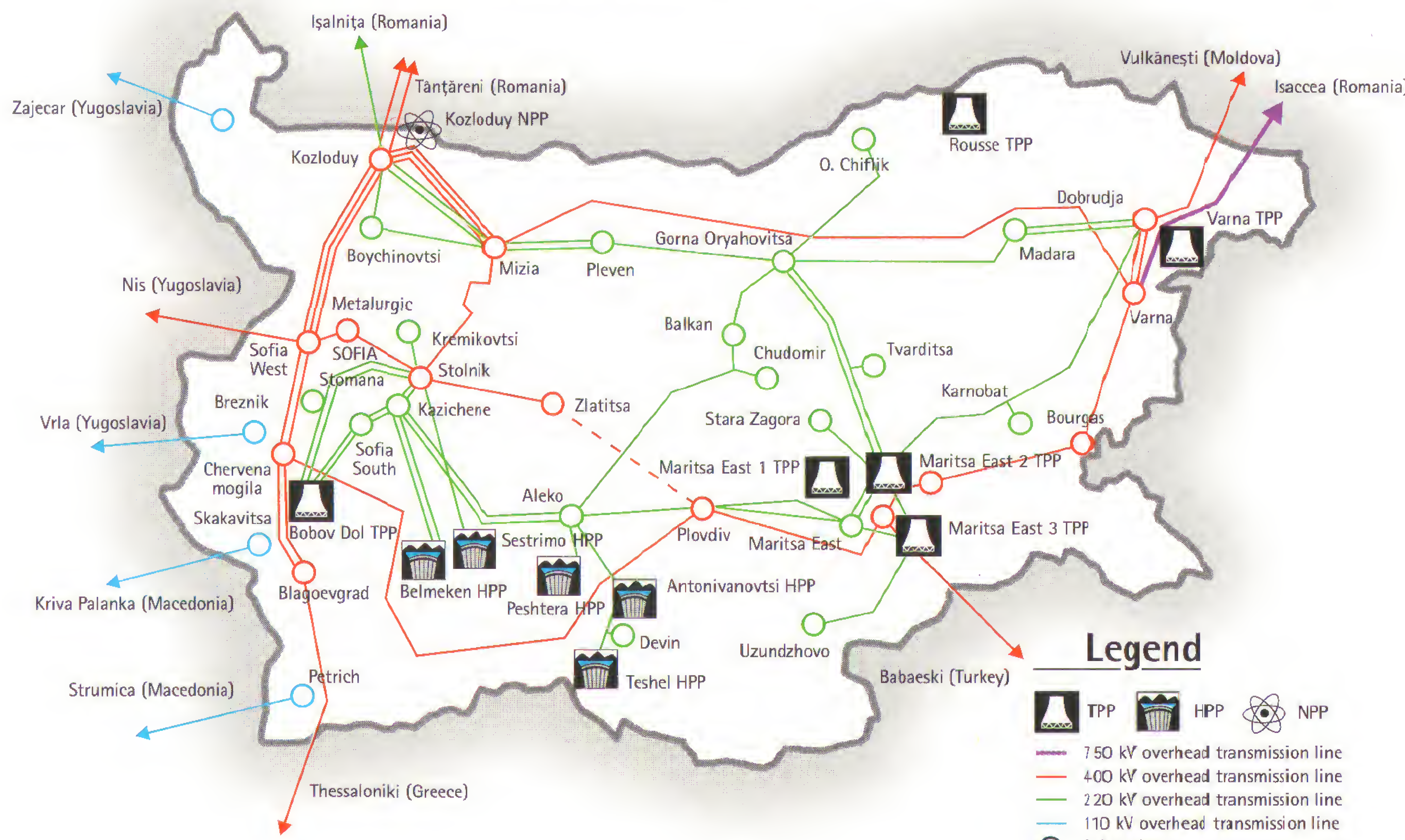


Fig. 20: Diagram of the 400, 220 and 110 kV transmission system in Bulgaria, 1990



Erection of a 400 kV overhead transmission line

20 kV steel-lattice tower with 20/0.4 kV distribution transformer

The absolute load maximum was reached in 1989 (12th December)-8332 MW, and the absolute load minimum-3083 MW (on September 5th). The annual utilization ratio at maximum load was T=5841 h. The extreme load value ratio was 0.456 which shows a comparatively good load curve density.

After 1988 there was a general decrease in electricity demand due to the decrease of industrial production as a whole.

Considerable success was achieved in railway transport electrification covering 2640 km electrified railways in 1990, i.e. 61.4% of their total length. The relative share of electric traction in the total volume of cargo carriage reached 82.2%.

20 kV overhead distribution line-
steel-lattice tower

20 kV double-circuit distribution line
concrete pole

5

Development of Electrification in the Market Economy after 1991

The electrification authority underwent considerable structural changes after 1989 when a democratic rule was established in Bulgaria (November 10th 1989). On January 1st, 1992 a single-owner state-property commercial company-Natsionalna Elektricheska Kompania (Bulgarian Electric Utility), was set up with the Committee of Energy, and the local power generation and power supply enterprises, as well as the investment enterprises (Integrated Works until then) became subdivisions of the Bulgarian Electric Utility.

Due to a serious general decline of the Bulgarian industry as a whole, the generation and consumption of electric power has also significantly decreased. Household electricity consumption, however, has retained its level and even marked a certain growth. Tables 17 and 18 show the electricity generation and consumption during that period.

Table 17: Installed capacities and electricity generation in Bulgaria

Year	Thermal Power Plants		Hydro-power Plants		Nuclear Power Plants		Total		Total max. load
	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW
1945	80	231	47	170			127	401	58
1950	111	530	65	267			176	797	113
1955	298	1 425	134	648			432	2 073	346
1960	465	2 768	460	1 889			925	4 657	808
1965	1 357	8 243	770	2 005			2 127	10 248	1 591
1970	3 264	17 357	814	2 158			4 075	19 515	3 295
1975	4 312	20 230	1 720	2 453	880	2 554	6 912	25 237	5 200
1980	5 666	24 957	1 868	3 713	1 320	6 165	8 854	34 835	6 922
1985	6 508	26 265	1 975	2 236	1 760	13 131	10 913	41 632	7 878
1988	6 574	26 395	1 975	2 596	2 760	16 030	11 309	45 021	8 115
1990	6 402	25 624	1 973	1 851	2 760	14 655	11 135	42 130	8 110
1995	6 550	22 235	2 440	2 507	3 760	17 261	12 750	42 003	7 522
1997	6 550	22 119	2 872*	2 927	3 760	17 751	13 182	42 797	7 232
1998	6 550	21 471	2 872	3 316	3 760	16 899	13 182	41 686	7 257

* including two generating sets at the Chaira pumped-storage hydro-power plant, still in the process of construction (432/380 MW)

Table 18: Development of electric power generation and its balance (1989 – 1995)

Indicator	Measuring unit	1989	1990	1991	1992	1993	1994	1995
Resources	mln. kWh	49 265	47 528	42 000	38 899	39 628	39 349	43 964
Generation	mln. kWh	44 328	42 141	38 917	35 610	37 998	38 176	42 003
Import	mln. kWh	4 937	5 387	3 083	3 289	1 630	1 173	1 961
Export	mln. kWh	548	1 597	959	584	1 520	1 245	2 121
Net Consumption								
Industry	mln. kWh	19 149	14 925	13 173	13 173	12 353	12 793	N/A
Households	mln. kWh	10 183	10 475	10 405	9 685	10 021	9 806	10 956

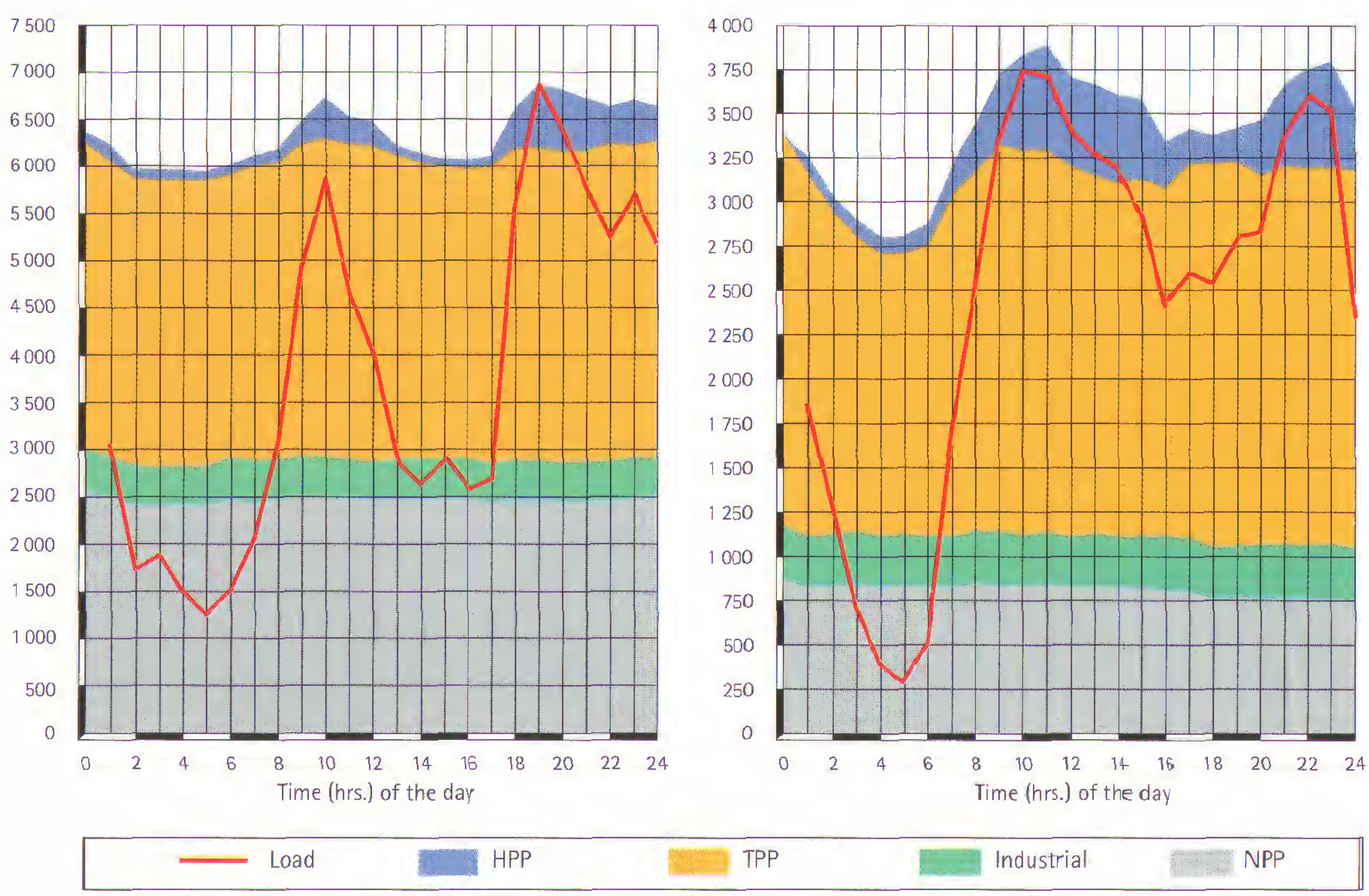
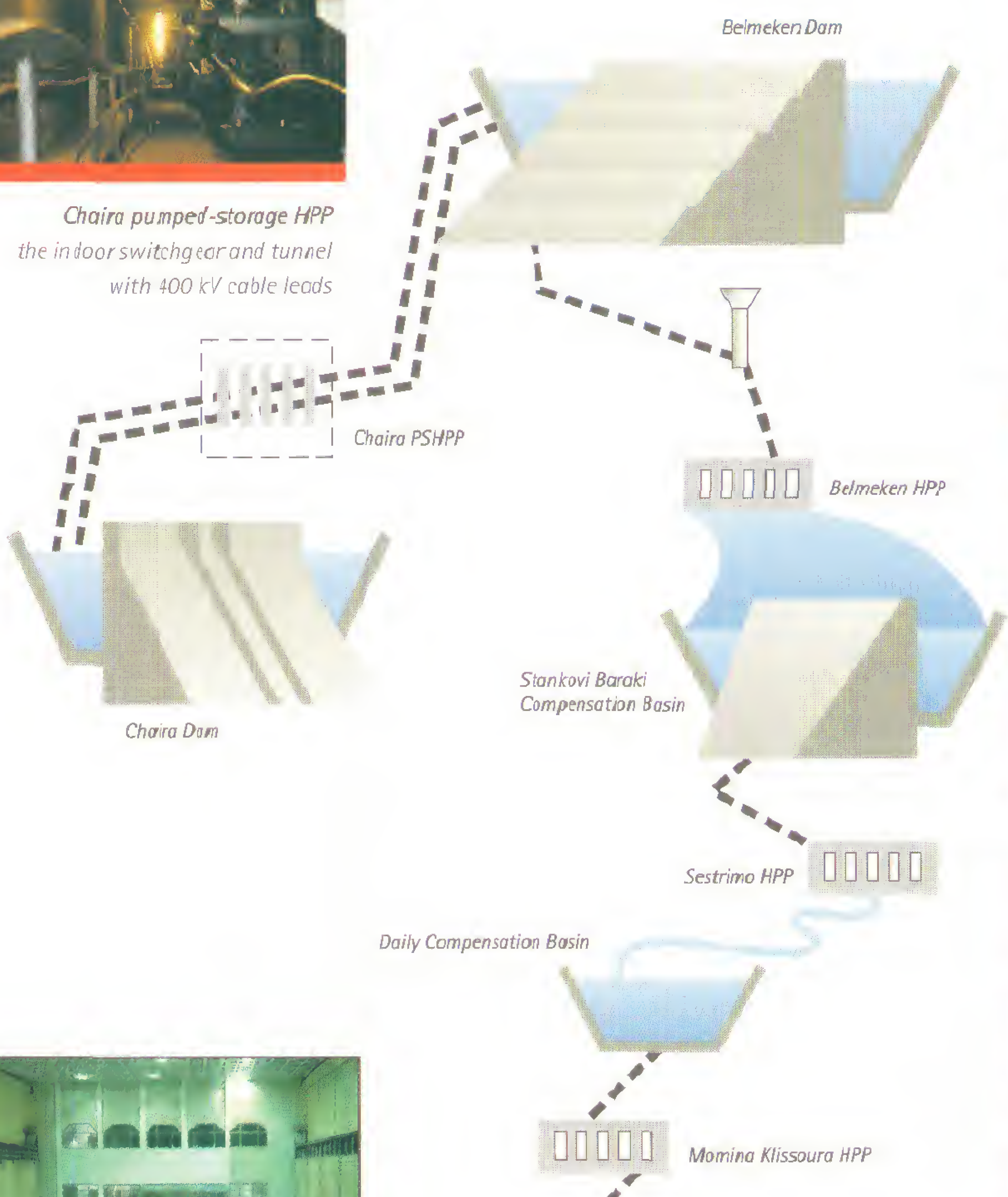


Fig. 21: Load curves in MW on typical days – in July (20.07.1994) and in December (21.12.1994)

Chaira pumped-storage HPP
the indoor switchgear and tunnel
with 400 kV cable leads

BELMEKEN-SESTRIMO-CHAIRA
Hydro-Power Cascade
commissioned between 1974-1995



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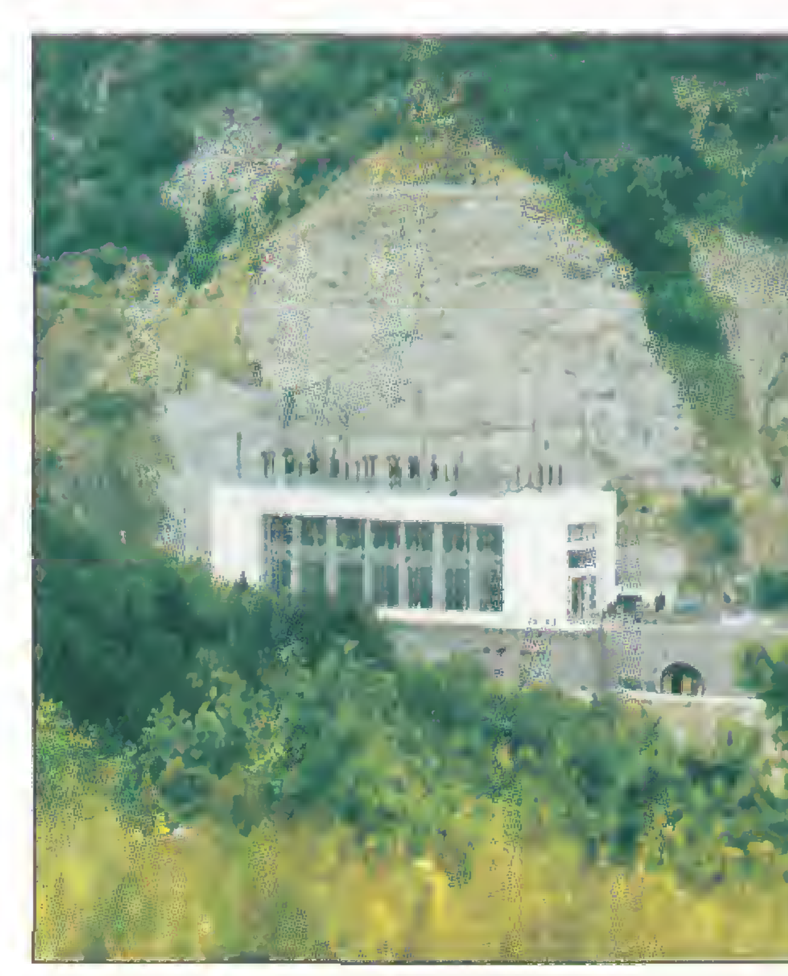

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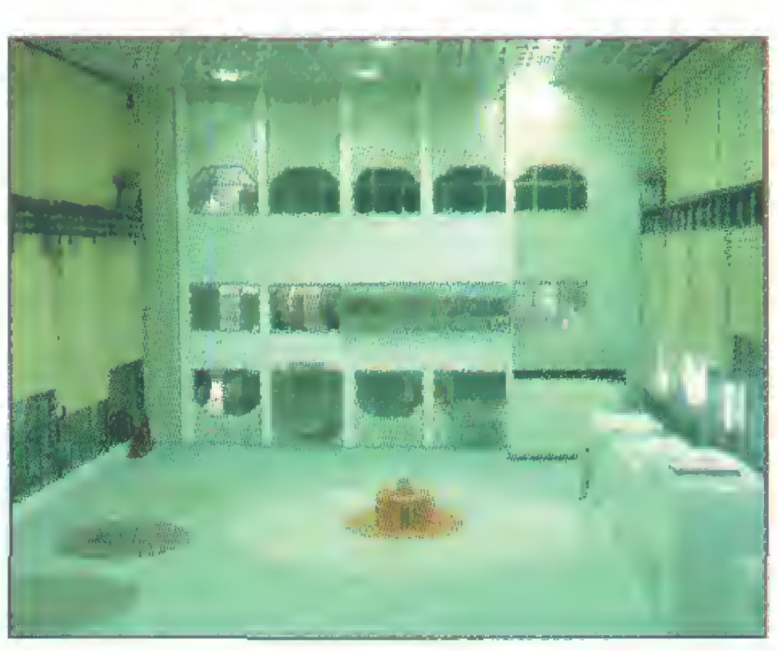

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1. *Belmeken HPP-PSHPP, commissioned in 1974*
2. *Momina Klissoura HPP, front view*
3. *Sestrimo HPP, front view*
4. *Chaira pumped-storage HPP – machine hall*
5. *Chaira pumped-storage HPP – the lower compensation basin*
6. *400 kV Vetren Nodal Plant*

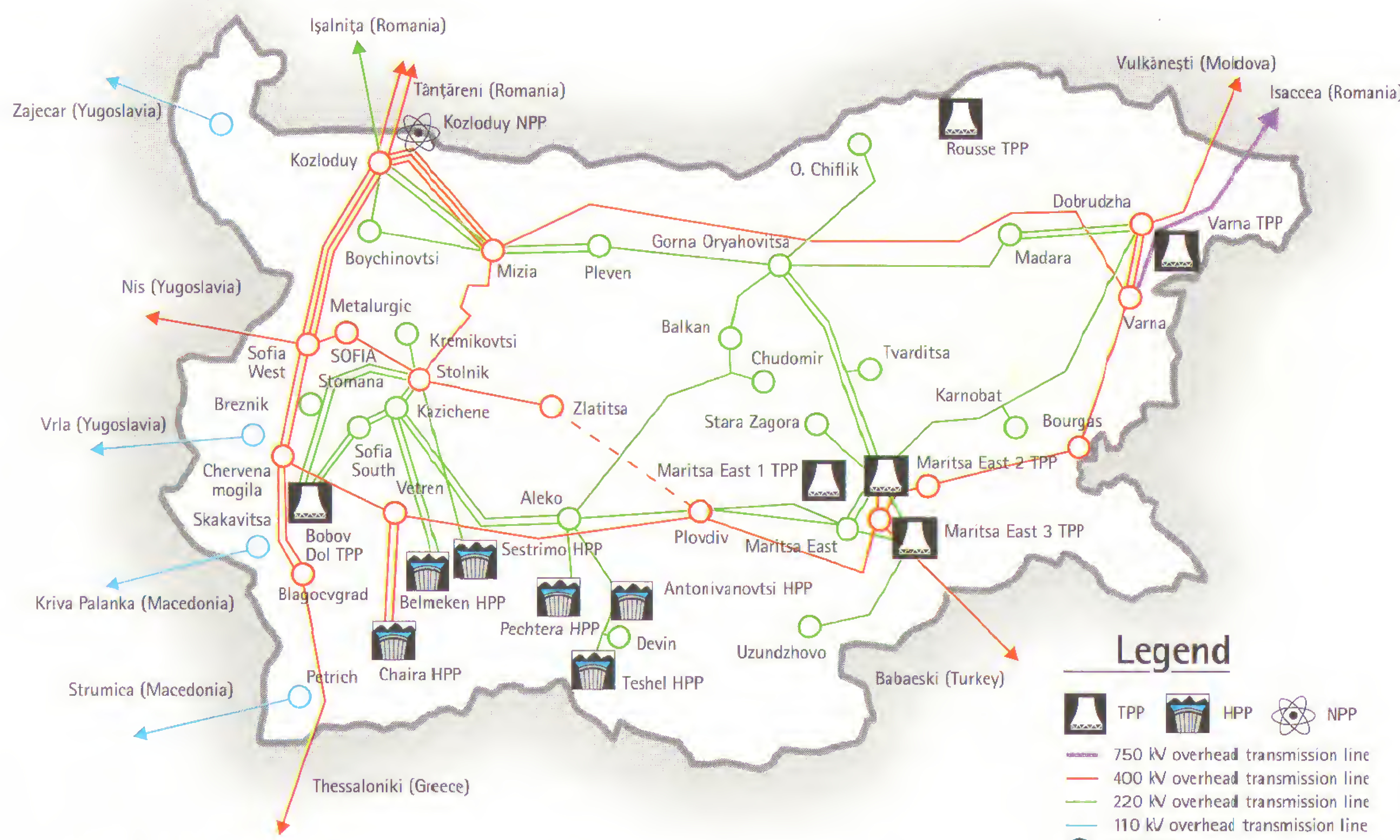
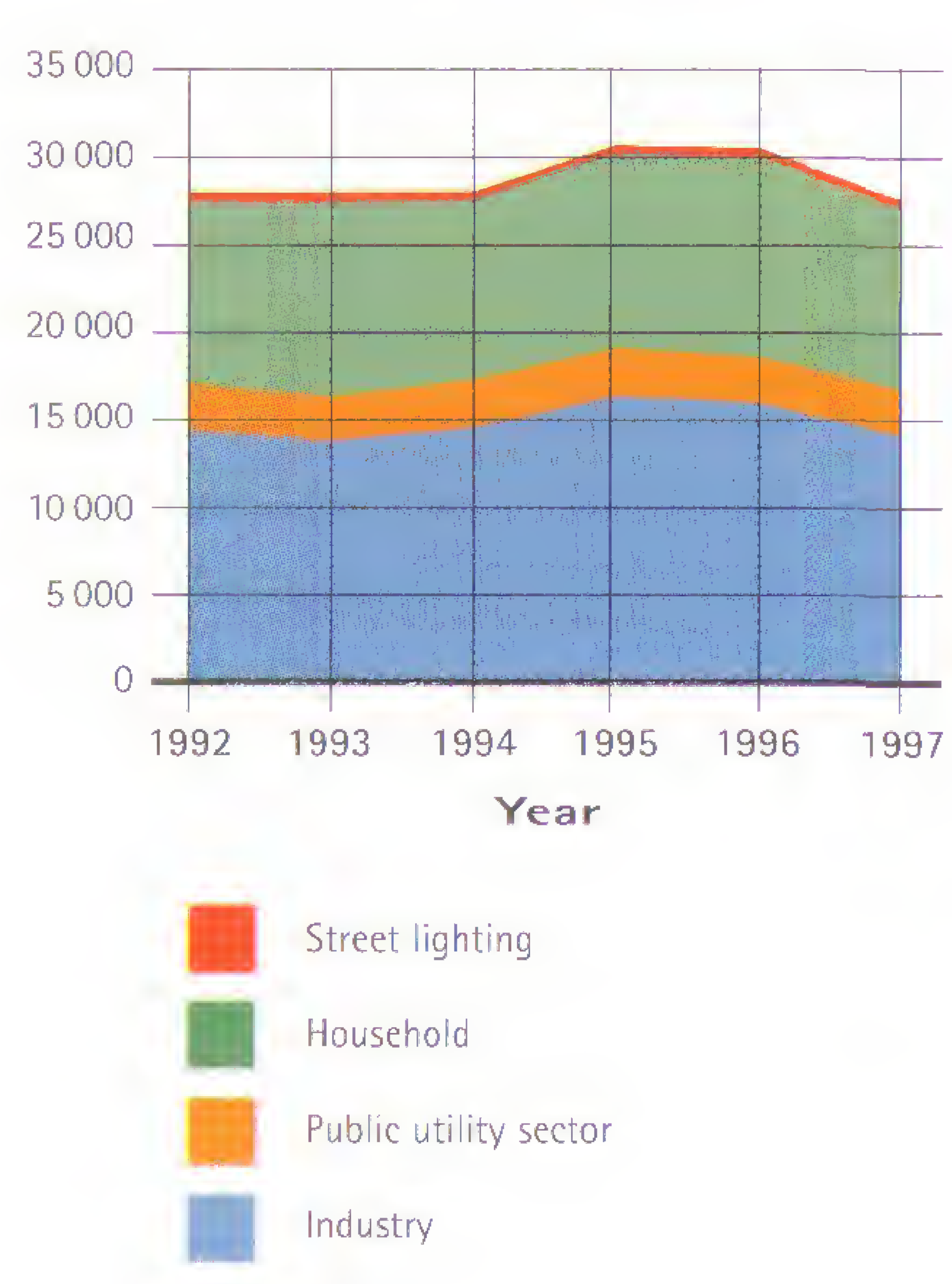


Fig. 22: Diagram of the Bulgarian Electrification System in 1995

Fig. 23: Electricity consumption in Bulgaria, million kWh



Electric power generation and consumption reached their minimum in 1992 after which there has been quite a small increase.

The construction of electricity transmission facilities also declined. The 400 kV connecting line between the Vetren nodal plant and the Chaira PSHPP was completed in that period, as well as the 400/110 kV Tsarevets Substation.

An energy development strategy was developed in 1995. It includes:

- up to 2000: urgent measures for stabilization of the sector;
- 2001-2010: middle-term forecast envisaging total electricity consumption of 49 billion kWh in 2005, and 52-54 billion kWh in 2010;
- 2011-2020: long-term forecast, according to which the expected electricity consumption in Bulgaria in 2020 should reach 58 billion kWh.

The long-term forecast of electricity consumption in Bulgaria may be considered as too skeptical, but in the event of a more favorable general economic development of the country, that forecast may be significantly exceeded.

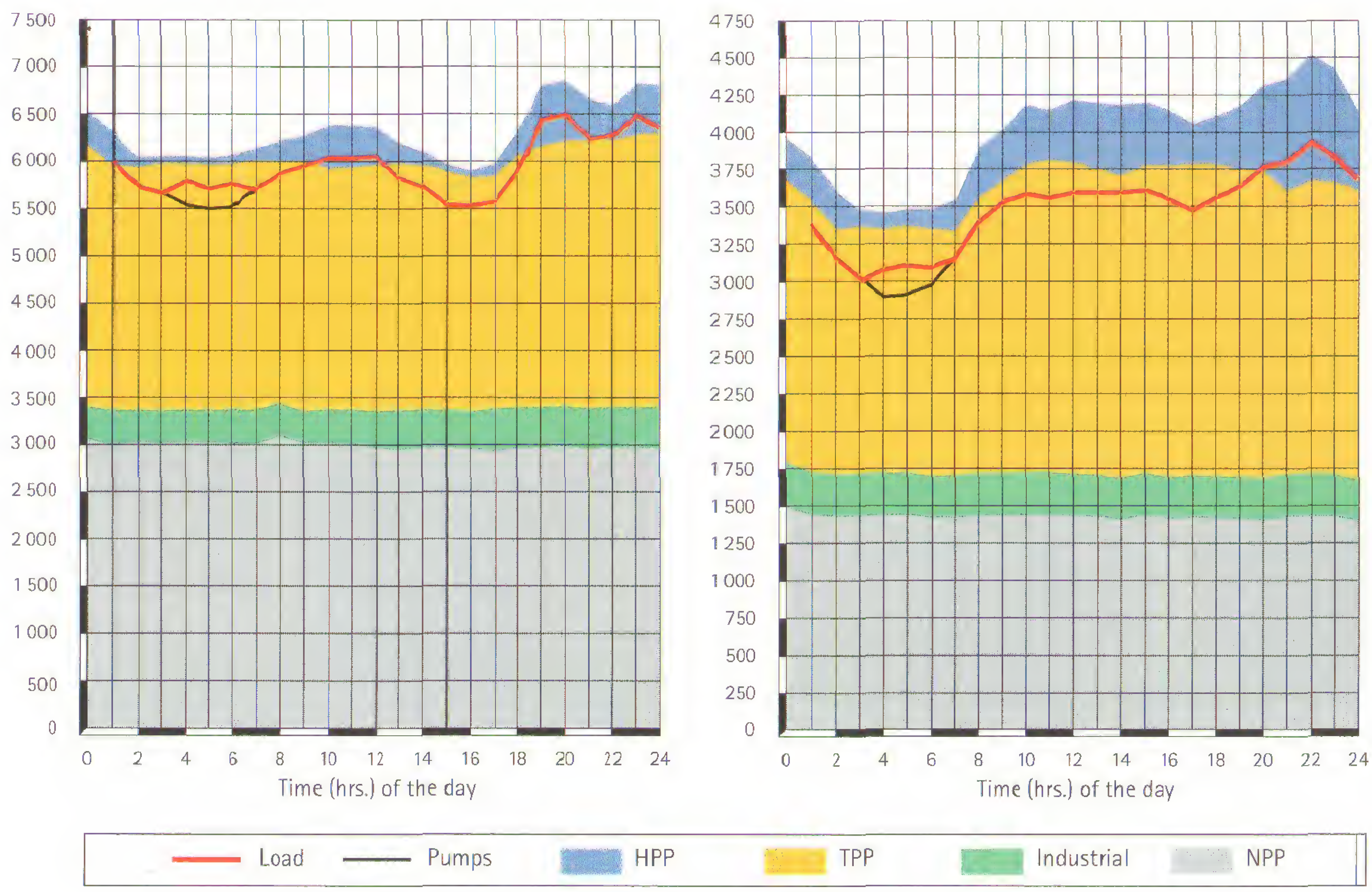


Fig. 24: Load curves on typical days in MW– in July (15.07.1997) and in January (22.01.1997)

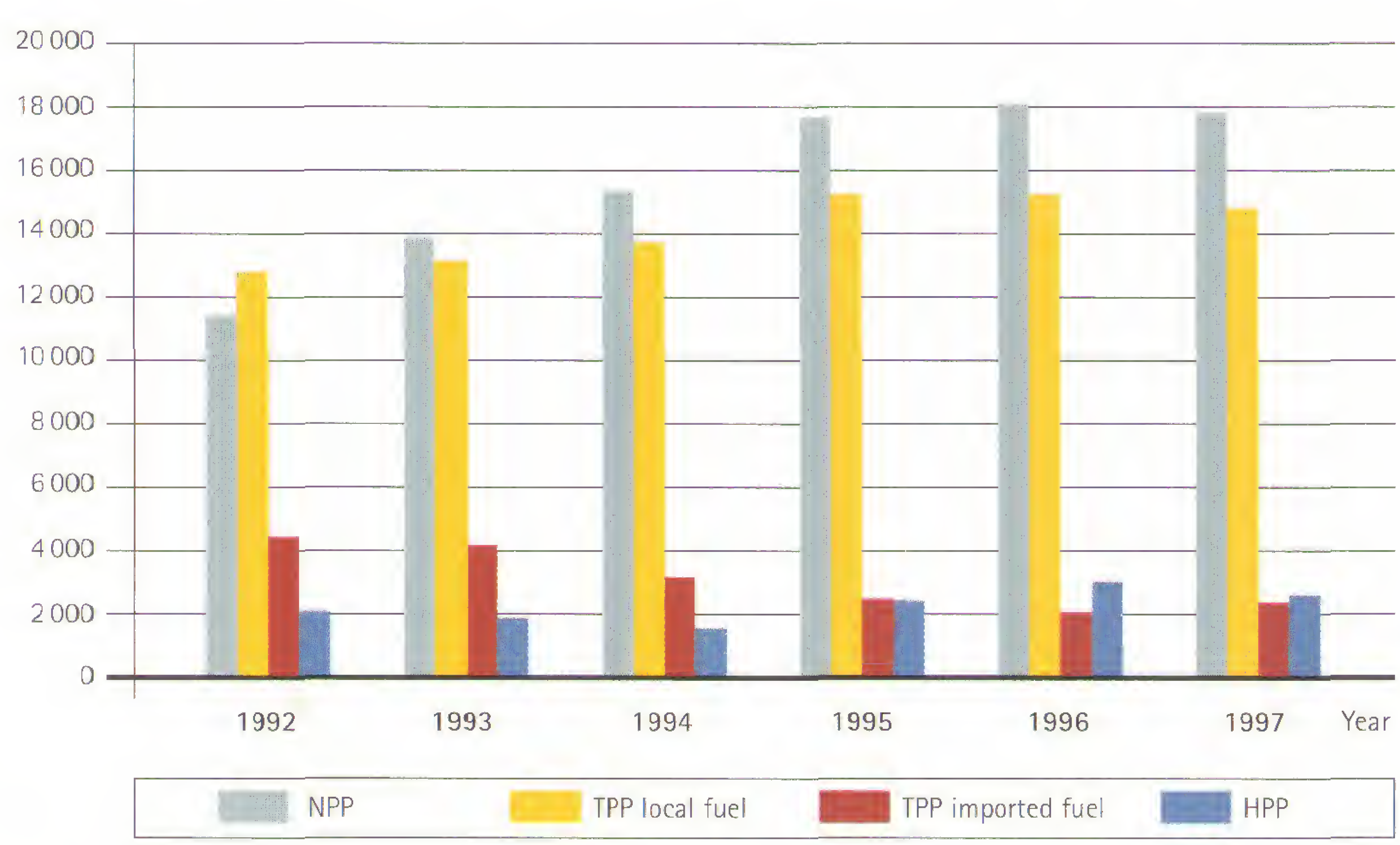


Fig. 25: Electricity generated by types of power plants, million kWh

6

Development of the Electrical Equipment Industry

Before the end of World War II there was no developed electrical equipment industry in Bulgaria worth mentioning but just rudiments of it. In 1926, the first asynchronous motors, small dynamos, transformers, circuit breakers, etc., were manufactured in a small private workshop. During the thirties, electric motors up to 7 hp were manufactured in small private workshops. In 1934 the manufacture of electrical bulbs was started in Sliven in a workshop employing 20 workers. And in 1935, a workshop manufacturing components for internal electrical installations was opened in Rousse.

Transformer production in Bulgaria also began at that time – in 1934, when the first oil transformers with 320 kVA average capacity were designed for the purposes of electrification.

Manufacture of insulated copper conductors started in 1932 in Sevlievo and during World War II such workshops were opened in Bourgas, as well.

All these small workshops were the beginning of future large factories and works which would be developed as state enterprises during the second half of the 20th century. They met the needs of the country for electrical products and some were exported, too. Initially such enterprises were transformed into factories united in an Electrical Industry Syndicate (1947). After the nationaization of industry in 1948 this syndicate was re-organized and turned into a state group – "Elprom" with the Ministry of Electrification and Amelioration. Elprom undertook the construction of several basic works and, in the first place, the High Voltage Equipment Works in Sofia. Three of the factories already existing in the city – for electric motors, for transformers and apparatuses, were moved into the new buildings of the works in 1949.

Many people would find it quite a strange idea to construct such huge works with workshops disposed on an area of 15 000 m² as was the case with the High Voltage Equipment Works in Sofia. However, the organizing talent and foresight of its founders led to its implementation.

The Soviet Union sent the first machines and experienced specialists who rendered significant assistance. At the same time the electrical company Ganz–Budapest became a patron of the High Voltage Equipment Works and commissioned its engineers to render help. The company provided a 3-year training course of Bulgarian experts in Budapest.

As the various product lines grew and expanded, the High Voltage Equipment Works split up into a number of new electrical works such as: Electrical Apparatus Works–Plovdiv; Elevator Factory–Sofia (1964); Iskra Works–Sofia for manufacture of manual low-voltage devices; Elprom Works–Varna for electrical household appliances and heaters, Lighting Fixtures Works in Stara Zagora.

Separate DC Equipment Works were built in Sofia in 1960. Besides, new works for electric motors were built in Troyan and Plovdiv, and mini-electric motor works–in Lovech and Teteven.

Transformer department at the High Voltage Equipment Works in Sofia

High Voltage Equipment Works in Sofia
the test laboratory

Thus, in 1967, the Elprom Group included 20 works, one research institute and 6 technological development centers at some of the works. And while in 1947 the Bulgarian electrical equipment industry met only 0.65 % of the needs of the country, in 1967 it met already more than 90 % of the demand, and constituted about 20 % of the total machine building in the country.

Electric motors are among the most important items in the production range of the High Voltage Equipment Works in Sofia. The Works recruited young electrical engineers among the first graduates of the State Technical University many of whom were holders of bursaries from Elprom. Young and ambitious, they joined the older and more experienced engineers in the fulfillment of the Works Programs. Later on, many of these engineers became ranking decision makers, highly qualified teachers, scientists, designers and technologists.

High Voltage Equipment Works in Sofia–
the test laboratory

As early as 1949, a package of technical documentation on a new developed series of general-purpose asynchronous low-voltage electric motors types "A" and "AO" of 10 kW or less for direct connection to the mains was received from the Soviet Union. With a view to the limited capacity of the Bulgarian electric power system, they had to be designed for indirect start, i.e. through star-delta switches. A Bulgarian series of electric motors of a new design–AM, and later on, AP and AOP, was developed. The Bulgarian designers developed more powerful asynchronous motors up to 100 kW (1951–1956).

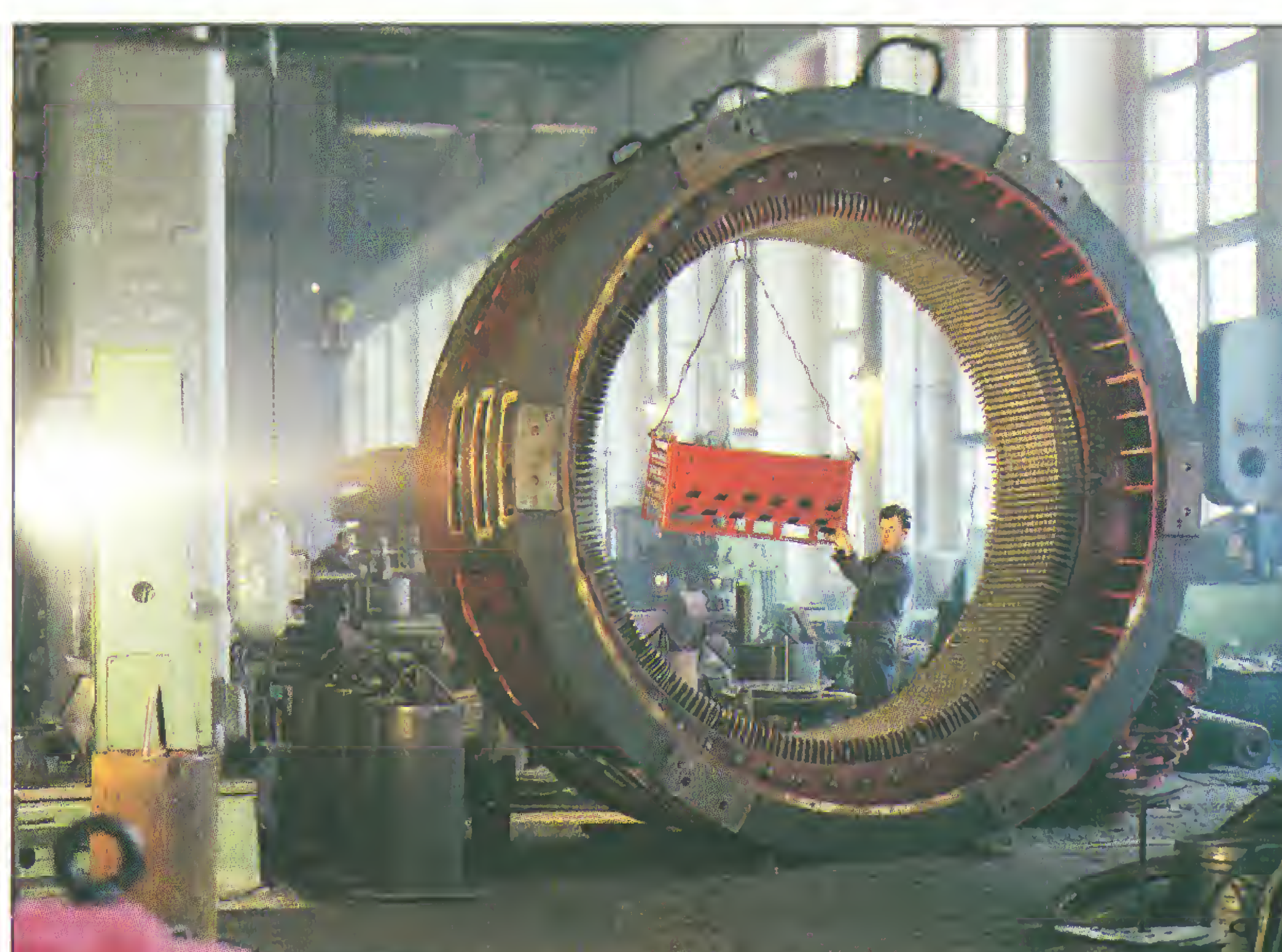
Within the period 1956–1958 the Bulgarian specialists created AO electric motors of an ingenious design with considerably smaller overall dimensions permitting saving of non-ferrous metals thanks to the better quality of the materials used, especially the enamel for conductor insulation and the rotor groove size. Thus the weight of the motors was reduced by about 30%. That motor design was adopted for manufactures from the COMECON–Eastern Europe.

The Apparatus Factory in Plovdiv which became an independent unit in 1952, developed and manufactured various types of automatic low-voltage circuit breakers, ballasts for fluorescent lamps, automotive switches and a number of other related products.

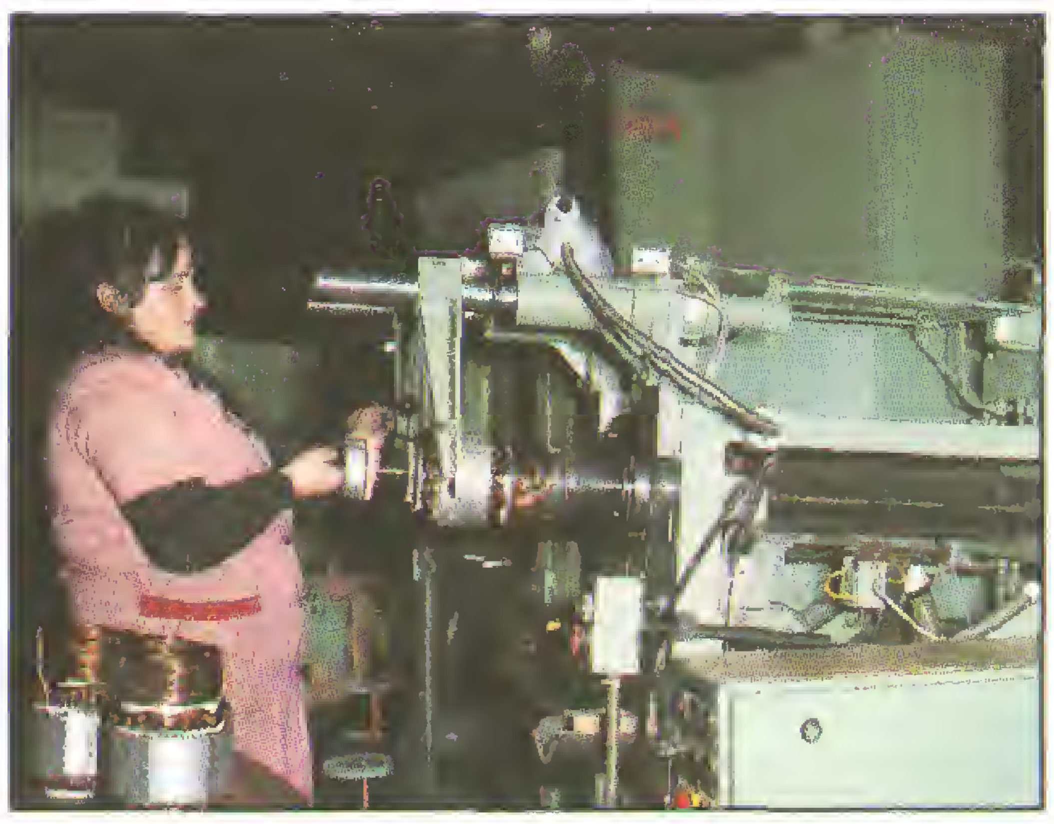
In the early fifties, the first Bulgarian hydro-electric generators were made: first for Ustovo HPP with 315 kVA output, 1000 rmp, and soon after that–for Studena HPP–with 500 kVA output, 1000 rmp, for Batoshevo HPP–with 1000 kVA output, 750 rmp, for Barzia HPP–with 4000 kVA output, 500 rmp, etc.

In 1962, a synchronous generator with 30 000 kVA output was made for Teshel HPP, then another for Krichim HPP with output 40 000 kVA, so every next hydro-electric generator manufactured was more powerful.

High Voltage Equipment Works in Sofia synchronous generator



These generators were completed with Bulgarian hydro turbines made at the specialized works in Pleven. There, in 1954 three Francis type hydro turbines with a capacity from 0.32 to 62 MW were produced. In 1967 2x30 MW Francis turbines were made for Teshel HPP. The manufacture of Pelton turbines with capacity between 1.5 and 130 MW was also mastered. In the period 1952–1970 were manufactured 71 turbines for 23 projects.



Manufacturing of electric motor collectors

In the meantime manufacture of other turbine equipment went on–penstock valves, spherical gate valves. Thus, the gate facility made for Sestrimo HPP was a penstock valve with 3.5 m clear opening, and for Momina Klissoura HPP–a spherical gate valve with 2 m clear opening and 83 t weight.

The Bulgarian transformer production was extremely successful. The first transformers made at the High Voltage Equipment Works in Sofia with 5600 kVA capacity for 20 kV, 35 kV, 60 kV and 110 kV were commissioned in 1951. And in 1957, the first Bulgarian 31 500 kVA, 110 kV transformer with an on-load tap-changer was produced.

The first 35 kV Yansen on-load tap-changer was manufactured in Bulgaria in 1954, and two years later the manufacture of 110 kV on-load tap-changers was started. Some Bulgarian inventions were applied in that area. The first 220 kV, 32 MVA transformer was manufactured in 1962, and a 180 MVA autotransformer–in 1965.

Yansen on-load tap-changers

The High Voltage Equipment Works in Sofia mastered and began manufacture of low-oil circuit breakers, disconnectors, drives, etc. The first low-oil circuit breaker was intended for 10 kV. The test results in 1951 were quite encouraging. Within 3-4 years a series of such 10 kV and 20 kV circuit breakers with rated current range up to 1000 A was implemented. The first 110 kV low-oil circuit breakers were made in1956.

Special conical-rotor motors were designed for the Bulgarian world-level electric hoists.

There was also a successful start in the manufacture of low-voltage apparatuses for switchgears, relays and devices for process control, automation and mechanization.

The Specialized Works in Rousse manufactured electrical installation and insulation materials. Two works in Sevlievo and Smolyan specialized in the manufacture of low voltage installation wires and cables. The Cable Works in Bourgas developed the manufacture of power and telephone cables. All these works grew up from the former workshops of the thirties and forties.

Porcelain insulators
at the plant in Nikolaevo–
Stara Zagora Region

Manufacturing of porcelain insulators at the plant in Nikolaevo–Stara Zagora district

The only works for porcelain insulators were constructed in Nikolaevo, Stara Zagora District. They were commissioned in 1951, and by 1967 82% of their production was intended for export. The works made 110 kV porcelain insulators, as well as insulators for high-voltage switchyards and for low-voltage networks.

The present review can hardly cover the Elprom Group vast production range manufactured at 20 works during that period. It is essential to say that the Bulgarian electrical equipment industry, along with and at equal level with the other branches has contributed a lot to the industrial image of our country. At the same time, the achievements in the period 1948–1970 were in fact accumulation of experience for further, higher achievements in the electrical equipment industry. After 1959, when the Ministry of Electrification and Water Resources was closed, the Elprom Group became subordinated to the Committee of Industry.

The products of the Bulgarian works from the Elprom Group won a number of prizes at international fairs and all that encouraged the research workers and design engineers at these works. Their production was well received both in the country and abroad.

The High Voltage Equipment Works in Sofia gradually became large-scale Electrical Equipment Works with the following main lines of production:

- **Electrical machines:** low-voltage general-purpose unified-series asynchronous motors, high-voltage electric motors, unique motors and electric motors with a special application.
- **Transformers:** power transformers for 110, 220 and 400 kV substations and for distribution networks, as well as current and voltage measuring transformers.

The Bulgarian series M and MO asynchronous electric motors were notable for their high technical, economic, energy and vibro-acoustic indices, and were awarded gold medals at the Plovdiv and Leipzig Fairs.

A number of works specially for distribution network electric motors and transformers were built in Troyan, Lovech, Kyustendil and Godech.

The Elprom-Belfa Works in Sliven mastered the manufacture of various electric light bulbs with the assistance of Tungsram–Hungary.

A range of asynchronous electric motors

After 1965 Bulgaria became specialized in the manufacture of electric trucks and electric hoists for the Bulgarian market and for export to the East European countries. Considerable quantities were also exported to other countries in the world.

The Bulgarian mini-electric motors made at the Elprom works in Lovech, Troyan and Teteven, as well as the various machines equipped with them, have become well known on the international markets. The Bulgarian electrical equipment industry is also very successful in the production of electrical drives for machine tools with numerical program control.

Bulgarian electrical equipment industry has achieved significant results also in the sphere of HV switchgear production. The range of low-oil circuit breakers type MMO for Voltage 72.5-245 kV and Rated Current 1250-1600 A meet the home market demand and considerable quantities are exported abroad, as well.

Since 1985 "Elprom-Avangard"-Sevlievo has been manufacturing, under the license of the Swedish company "ACEA" (now incorporated with Brown-Bovery as ABB) the most advanced SF_6 circuit breakers. They are intended for Rated Current 2500-4000 A and Breaking Current 40 and 50 kA, mainly for export.

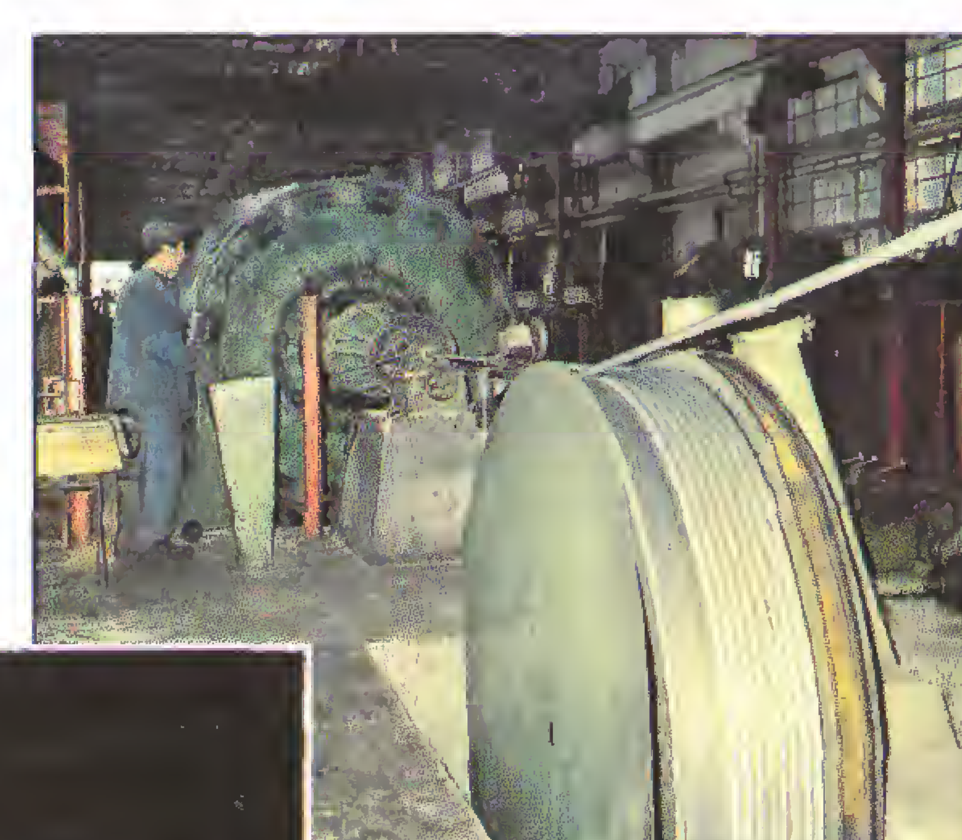
The disconnectors produced by Elprom–indoor and outdoor types, single pole and three pole ones, with or without earthing switches, with manual, pneumatic or motor drive, for current up to 630 A, meet the home market demand, many are also intended for export.

Manufacture of diesel generating sets

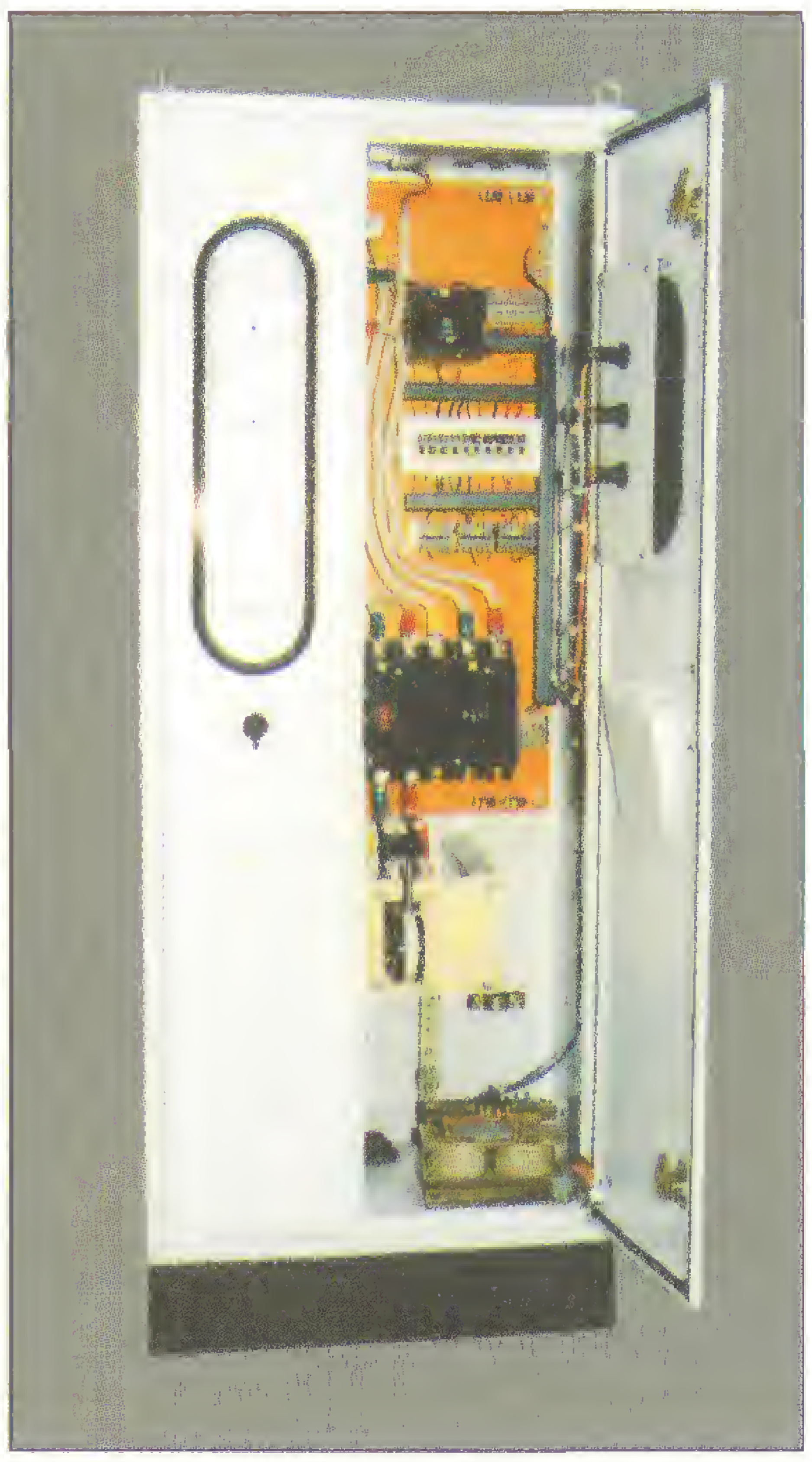
At present "Elprom-Thermo" Ltd-Balchik produces disconnectors for Voltage 66-132 kV and Rated Current up to 2000 A, as well as manual drives for outdoor disconnectors – up to 145 kV, operating under normal and tropical climatic conditions.

In 1964 a special branch "Cermet materials, special alloys and contact materials" was established with the Research Institute of Electrical Industry. In 1970 it became an independent institute.

From 1975 on all kinds of electrical equipment production was brought together in the Elprom-Energo Integrated Works, and for the purposes of research and development in that field, an Electric Power Technology Institute was opened in Sofia. The new group covered a wide range of rotary electrical machines, power and measuring transformers, on-load tap-changers, apparatuses and high-voltage complete devices, as well as electronic control systems for power generation, transmission and distribution. They all had a significant share in the investment development of power sector, machine building, chemistry, metallurgy and other branches of industry.



Manufacture of bare AC conductors for OHTL



LV switchboard

After 1974 Bulgaria had ingenious solutions and new technologies. It became a much sought-after manufacturer and exporter of on-load tap-changers for large power transformers. The annual output of on load tap changers came up to 2777 pcs, 96% of which were exported to more than 30 countries.

The Bulgarian unified series of high-voltage asynchronous electric motors of 200-1000 kW capacity created in 1976-1980 proved to be very competitive on the international markets. Powerful electric motors for the nuclear and thermal power plants were developed and manufactured. Five types of vertical electric motors for the secondary circuit of the nuclear power plant were introduced in production. Sixty asynchronous electric motors with 250, 500, 1000 and 1600 kW and double-speed motors with 800/400 kW capacity were manufactured for the Bulgarian nuclear power plant (1983-1988).

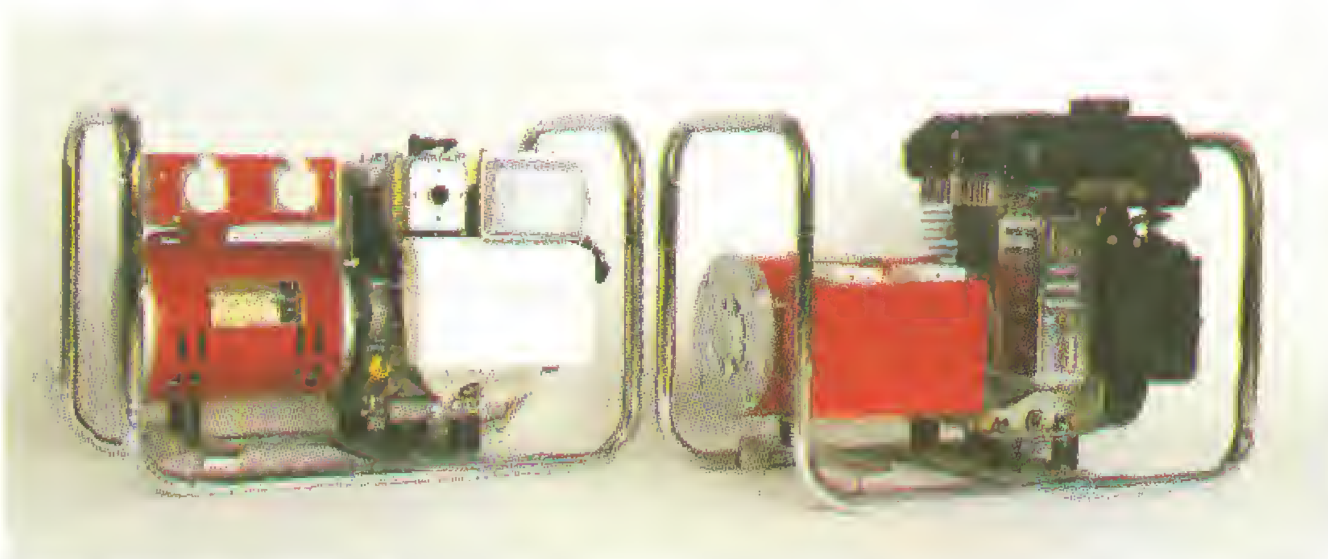
In the period after 1980 for the purposes of nuclear power production appeared a series of synchronous electric motors with static excitation system and automatic excitation control within the range 250-1600 kW.

The summit of electric power industry in Bulgaria has been marked by the adoption of motor-generator units–a new production technology together with the Japanese company Toshiba for the needs of the Chaira PSHPP. The reversible motor-generator units are 240 MW, 19 kV, 600 rpm and are among the most complex electrical machines at that time.

Motor-generator unit
in the machine hall of Chaira PSHPP

Within the period 1970 – 1980 the overall output of the electrical equipment industry increased about 3 times (Fig. 26)

Diesel generating sets



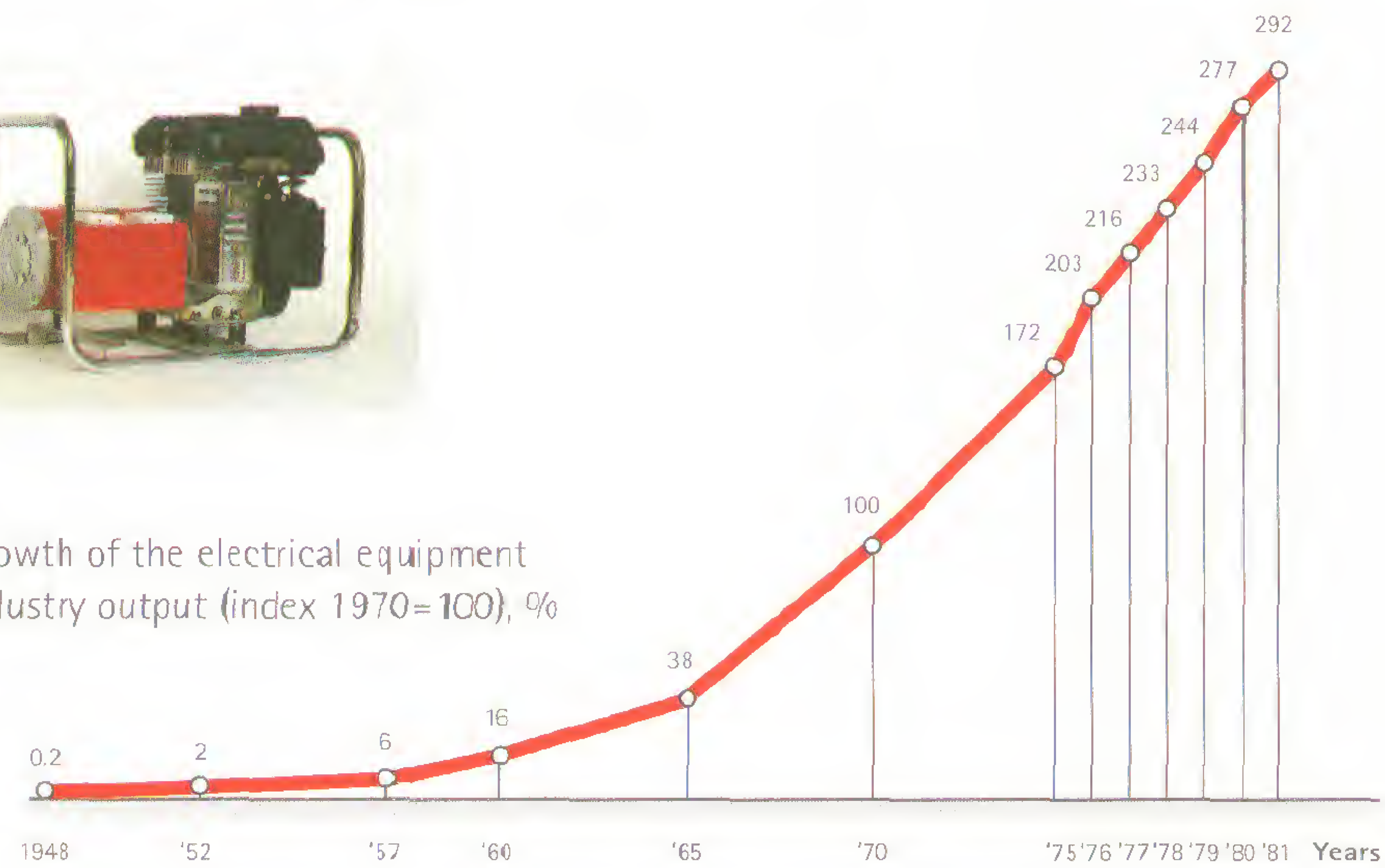


Fig. 26: Growth of the electrical equipment industry output (index 1970 = 100), %

On the basis of expanded production capacities and their intensive utilization, the output of some main groups of electrical products was significantly increased (Table 19).

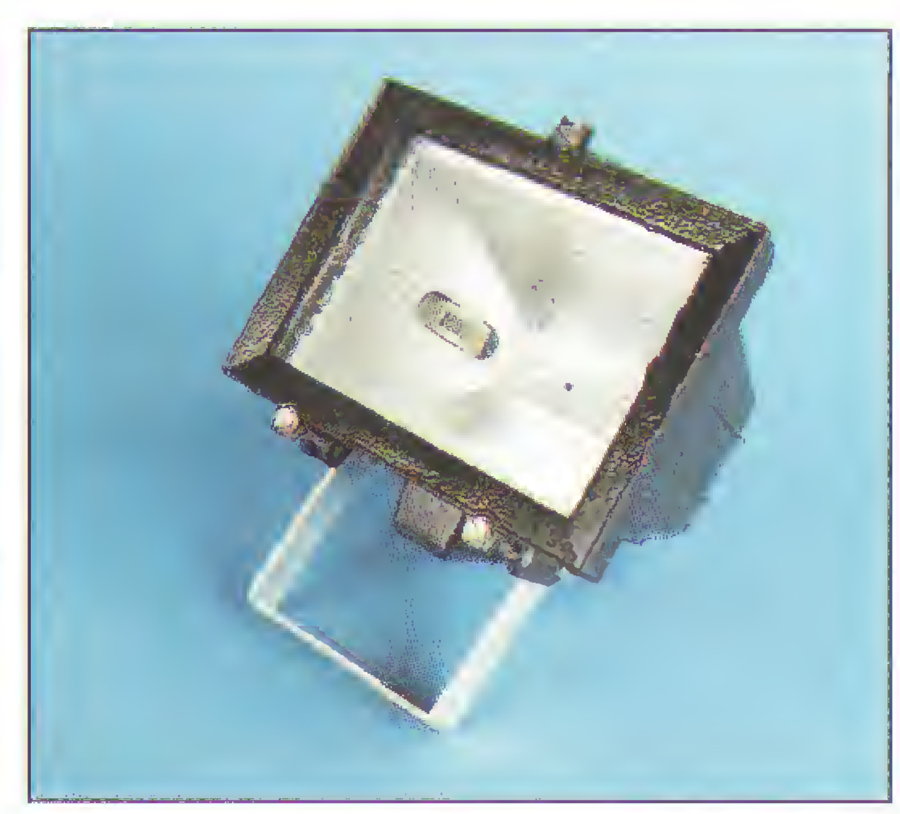
Table 19: Output of some main groups of electrical industry products

Branch/Year	Measuring unit	1970	1975	1980	1985	1988
Electric generators	pcs	515	1 414	1 694		
	thousands kW	37.0	32.5	70.9		
Electric motors	thousands pcs	750.5	947.3	1 251.4	1 401.3	1 890.7
	thousands kW	4 194	5 117	7 111	6 652	6 111
Power transformers	pcs	4 807	6 179	7 645	9 357	18 281
	thousands kVA	3 256	3 924	4 136	4 744	4 472
Generating sets	pcs	368	1 163	1 450	3 129	3 772
	kW	2 455	26 746	48 516	80 000	126 400
Cables	thousands m	24 030	40 701	56 016	68 698	66 213
Electric washing machines	pcs	56 342	73 321	64580	155 900	168 900

Table 20 presents the development of the two main groups of electrical products typical of that industry.

Table 20:

Unit	Year										
	1939	1948	1950	1956	1960	1965	1970	1975	1980	1985	1988
Electric Motor Production											
pcs x 10^3		3.0	14.2	122.7	236.0	497.1	750.5	947.3	1 251.4	1 403.3	1 890.7
kW x 10^3		5	65	105	919	2 864	4 194	5 117	7 111	6 652	6 111
Power Transformer Production											
pcs	17	187	860	907	3 924	4 224	4 807	6 179	7 645	9 357	18 281
kVA x 10^3		33	160	427	1 172	2 672	3 256	3 924	4 135	4 744	4 472



Various lighting fixtures

The wide product range of the Bulgarian electrical equipment industry has had a constant and steady development in terms of quantity and quality and has found a good acceptance on the international markets.

Electrical installation components

After 1989 when democratic rule replaced totalitarian rule, a structural reform has been carried out in the industry, including the electrical industry. The reform consists of privatization of the industrial enterprises which used to be a state property before that. All that has led to a certain decrease in the electrical industry output which has affected its international markets, quite well developed until then.

Various household appliances

7

Design and Fulfillment of Electric Power Projects Abroad

ELECTROIMPEX and the Bulgarian Presence around the World

As already mentioned, the steady growth of electrification in Bulgaria in the second half of the 20th century also had a great impact on the design and fulfillment of electric power projects abroad. The beginning was laid in 1960 with the establishing of Electroimpex as a foreign-trade enterprise with exclusive rights in Bulgaria on the import and export of electrical goods and equipment. In the first years Electroimpex established business relations with companies from 16 countries in the world. From the very beginning of its existence Electroimpex was involved in and contributed with its specialization to the development of the electric power system, as well as to the establishment of the electrical industry in Bulgaria. The efforts were directed to overall co-operation and participation in laying the foundations and the development of a market-oriented electrical industry on the basis of full compliance with the requirements and recommendations of IEC and the most widely applied international standards such as BS, DIN, etc. As a result of the efforts made jointly with the manufacturers, Bulgarian electrical goods and equipment found their place on the international markets.

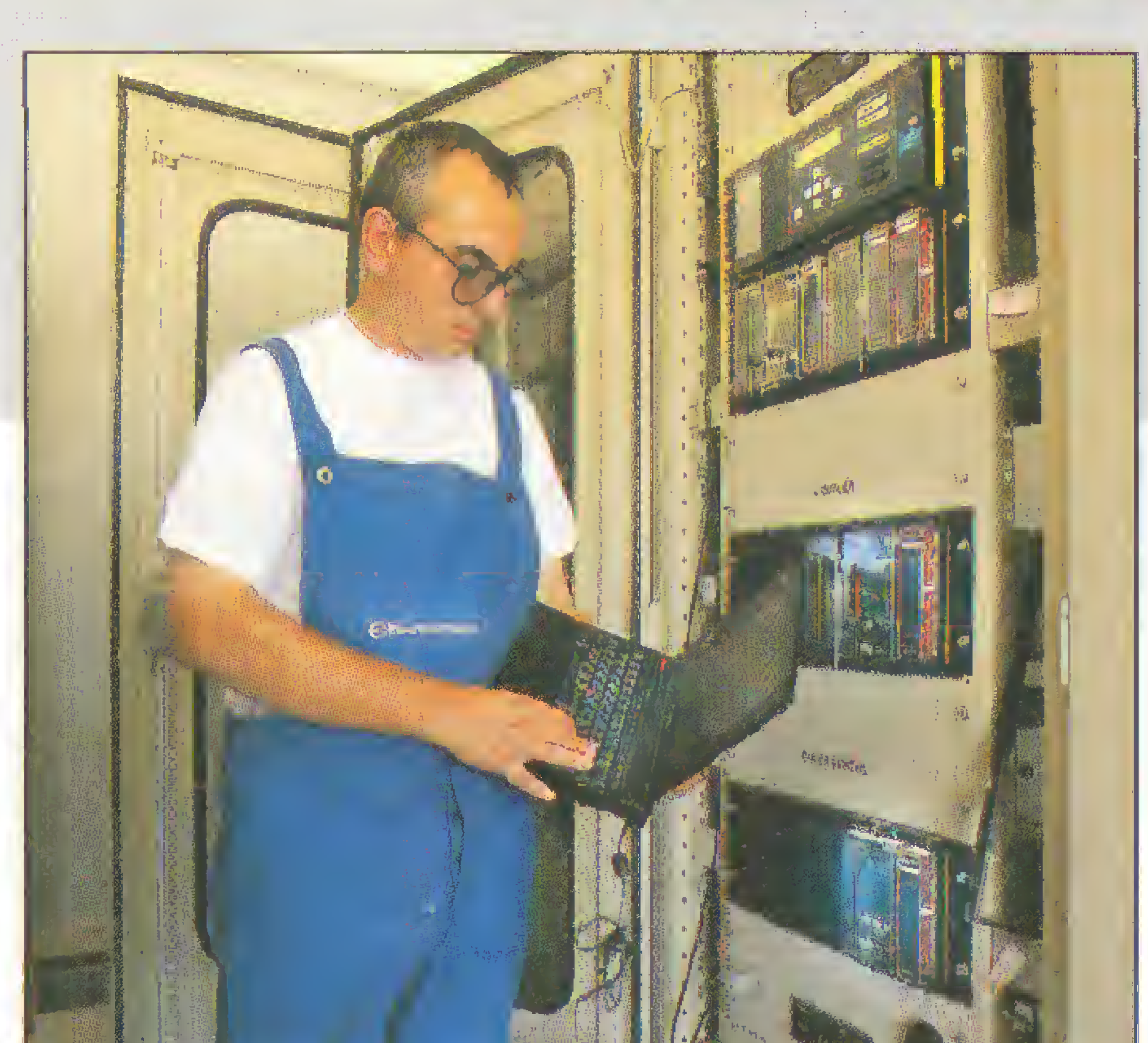
220 kV Hurgada Substation– Egypt

Thanks to its own policy and the development of the Bulgarian electrical industry, a few years after its establishment the company began to offer engineering services, as well. At that time they consisted mainly in the organization of complete projects performed by specialized Bulgarian subcontractors. During that period, in parallel with the projects performed, Electroimpex acquired the potential, experience and reputation of a company famous in the field of engineering activities.

Design work for 66/11 kV Hurgada Substation

In 1990 Electroimpex was transformed into a public limited company the founders of which included Bulgarian manufacturers of major electrical equipment, research and design institutes, banks, etc. In 1999 the company was privatized through Sofia Stock Exchange.

Construction of 63/20 kV Bostam Substation–Iran



Setting of secondary commutation–Egypt

132 kV Overhead transmission line–Kuwait

Today Electroimpex, with its 210 employees in the head office, independently performs engineering activities in the field of electric power projects: design, supply, installation, adjusting tests, commissioning, supervision, guarantee and post-guarantee services. On the basis of its own potential of engineers, economists and other highly qualified specialists, equipment and facilities, the company provides, by its own efforts, up to 35% of the complete engineering product of the carried out projects for electric power generation, transmission and distribution. It is in projects of that type only that the facilities are offered by Bulgarian and foreign subcontractors in strict conformity with the customers' requirements and the respective tender documents. Some of the best known manufacturers such as ABB, Alstom, General Electric, Schneider Electric, Siemens, etc. appear in Electroimpex List of Approved Suppliers.

66 kV Overhead transmission line
Sour Substation–South Lebanon

Electroimpex is awarded a Certificate of Approval by Bureau Veritas Quality International in compliance with Quality Standards BS EN ISO 9001:1994

in the field of engineering services for complete turnkey electric power projects, including: HV substations, HV overhead transmission lines, distribution overhead and cable networks, rural and urban electrification, hydro power plants, irrigation and water supply pump stations, package potable water treatment stations, technological lines and factories for electrical goods manufacturing.

The company is also included in the DG1A Central Consultancy Register of the European Community.

Indoor 66/11 kV, 3x25 MVA
Nadi El Remaya Substation–Egypt

66 kV overhead transmission lines
Saida Substation–Lebanon

Transportation of 220 kV transformer to Egypt

Electroimpex is well known in more than 85 countries in Asia, Africa, Europe and South America and in some of them, such as Germany, UK, France, Italy, Greece, Albania, Russia, Ukraine, Egypt, Syria, Iraq, Nigeria, Afghanistan, Lebanon, Jordan, Iran, Pakistan, Nicaragua, Cuba, Peru, etc., it has established business contacts with firms with a wide range of activities on the basis of joint-ventures, agencies or traditionally maintained cooperation contacts.

The company has implemented contracts with 18 countries in the world for about 100 projects worth more than 500 million USD and has become a well-known and welcome partner on the international markets.

The analysis of the financial condition of the company performed in conformity with the international auditing standards by the auditor firm KPMG show that Electroimpex is a successful company with stable economic indices, typical of which is 60 mln. USD annual turnover for the period 1992–1998.

All these facts and figures show that Bulgaria has significant achievements and experience obtained in the process of construction of a number of turnkey power projects abroad which is a warrant for stable and reliable partnership with foreign companies.

APPENDIX

ELECTROIMPEX OVERSEAS COMPLETE PROJECTS

	Year of completion	Value of completed projects in USD'000
ALBANIA		
• Two 35/10 kV, 2x10 MVA Substations	1979	2 700
• Supply of complete equipment and materials for Medium Voltage Distribution Network	1993	5 000
AFGHANISTAN		
• KANDAHAR 110/20 kV, 2x25 MVA Substations	1985	3 400
• Twelve 110/20 kV, 1x4 MVA Substations	1985	9 000
• DJANGLAG 15/6 kV, 2x2 MVA Substation	1985	1 500
• 110 kV, 10 km Overhead Transmission Line	1987	4 700
• 20 kV, 300 km Distribution Network	1987	1 200
• 660 km Low Voltage Distribution Network	1991	1 400
BANGLADESH		
• CHITAGONG 33/11 kV, 2x5 MVA Substation	1980	680
• MONGLA 33/11 kV, 2x5 MVA Substation	1985	640
CHINA		
• Thirty mini Hydro Power Plants with capacity 2 MW	1961	24 000
CUBA		
• Fifty Irrigation Pump Stations	1988	45 000
• 33/6 kV, 2x10 MVA Substation	1988	1 800
EGYPT		
• EDFU 132/33/6 kV, 4x40 MVA Substation	1980	8 500
• EL SUEZ Petroleum Industries 66/11 kV, 4x25 MVA Substation	1995	4 800
• HELWAN UNIVERSITY 66/11 kV, 3x25 MVA Substation	1996	3 500
• EL MOKATTAM 66/11 kV, 3x25 MVA Substation	1996	3 500
• EL MAADI 66/11 kV, 3x25 MVA Substation	1996	3 950
• ESKAN EL DOBBAT 66/11 kV, 3x25 MVA Substation	1996	3 600
• EL ISMAELIA 66/11 kV, 4x25 MVA Substation	1996	4 450
• EL DAWAGEN 66/11 kV, 3x25 MVA Substation	1996	3 400

• GEZERT EL DAHAB 66/11 kV, 4x25 MVA Substation	1996	4 050
• NADI EL REMAYA 66/11 kV, 3x25 MVA Substation	1997	3 500
• PORT FOUAD 66/11 kV, 4x25 MVA Substation	1997	4 000
• ZAHRAA MADENT NASR 66/11 kV, 4x25 MVA Substation	1997	3 600
• SHERATON 66/11 kV, 4x25 MVA Substation	1997	4 300
• MASNAA 200 EL HARBY 66/11 kV, 3x25 MVA Substation	1997	4 200
• EL-AKHMAS 66/11 kV, 2x25 MVA Substation	1998	4 820
• WADY EL-NATROON 66/11 kV 2x25 MVA Substation	1998	4 958
• HURGADA 66/11 (22) kV, 6x25 MVA Substation	1998	7 710
• EAST QUANTARA 220/66/22 kV, 125 MVA Transformers	1998	1 700
• BILBEIS EL-BADALA 66/11 kV, 3x25 MVA Substation	1999	5 760
• KARMOUZ 220/66/11 kV, 125 MVA Transformers	1999	1 700
• HURGADA 220 kV Substation	1999	5 000
• ABOU GALEB 66/11, 4x25 MVA	1999	5 760

IRAN

• Plant for manufacturing of contactors: 400 000 ps. annually	1984	1 500
• 230 kV, 244 km OHTL, Delivery of Steel Lattice Towers for FREC	1991	2 800
• Five 63/20 kV Substations for SREC	1997	6 800

IRAQ

• Contract HT-25 including:	1984	9 000
– BAGHDAD–NAHRAWAN 132 kV 31 km Overhead Transmission Line		
– HAMRIN-KHANAKIN 132 kV, 95 km Overhead Transmission Line		
– DOHUK–ZAHO 132 kV, 54 km Overhead Transmission Line		
• Contract H-39 TAMIM-TOSLUDJA-DOKAN 132 kV, 166 km Overhead Transmission Line	1985	8 100
• Contract HT-52 including:	1987	17 800
– NASIRIA-NASIRIA NORTH 132 kV, 13 km Overhead Transmission Line		
– KADISIA-DIWANIA 132 kV, 10 km Overhead Transmission Line		
– KADISIA-SAMAWA 132 kV, 86 km Overhead Transmission Line		
– NADJAF-NADJAF NORTH 132 kV, 10 km Overhead Transmission Line		
• 400 kV–4 km, 132 kV–2.5 km Overhead By-pass Interconnections	1987	880
• Lighting of Highways R-5 and Crossings	1990	1 600

JORDAN

• ZARKA IRBID 132 kV, 55 km Overhead Transmission Line	1978	2 100
• PHOSPHATE MINES 60 kV, 23 km Overhead Transmission Line	1978	1 200
• EL HASA 60/6.6 kV, 6.3 MVA Substation	1978	650
• EL ABAID 60/6.6 kV, 6.3 MVA Substation	1982	650
• TEFILIA and SHOUBAK rural area 11 kV, 53 km Overhead Transmission Line and rural area 0.415 kV, 220 km Distribution Networks	1982	3 750

KUWAIT

• ABDULA-SAUD 132 kV, 28 km Overhead Transmission Line	1974	1 900
• SAUD-WAFRA No1 33 kV, 30 km Overhead Transmission Line	1977	800

LEBANON

• BYKFAYA-KSARA 66 kV, 7 km Overhead Transmission Line	1974	150
• DAMOUR-SAIDA 66 kV, 18 km Overhead Transmission Line	1977	350
• LEBANON NORTH-SYRIAN BORDER 220 kV, 31 km Overhead Transmission Line	1979	1 000
• JAMHUR-BSALIM 150 kV, 11 km Overhead Transmission Line	1979	400
• SIBLIN 66/15 kV, 2x20 MVA Substation	1982	3 200
• JEITA 66/15 kV, 2x20 MVA Substation	1982	3 200
• AWALI-BAUSHRIE 66 kV, 6 km Overhead Transmission Line	1983	500
• BARED-HALBA 66 kV, 11 km Overhead Transmission Line	1983	300
• HALBA 66/15 kV, 2x20 MVA Substation	1983	2 900
• HERMEL 66/15 kV, 2x20 MVA Substation	1983	2 900
• ZOUK-BSALIM 150 kV, 10 km Overhead Transmission Line	1984	400
• MAMELTEIN 66/15 kV, 2x20 MVA Substation	1984	3 400
• KOBAYAT-HERMEL 66 kV, 25 km Overhead Transmission Line	1985	500
• ZOUK-JAMHOUR, 150 kV, 17 km Overhead Transmission Line	1990	2 000
• BEITEDIN 66/15 kV, 2x20 MVA Substation	1990	3 500
• DBAIEH and ASHRAFIEH Water Pump Stations	1990	1 000
• ZOUK-BSALIM Overhead Transmission Line 150 kV (reconstruction)	1991	430
• CHOUEFAT-DAMOUR Overhead Transmission Line 66 kV (rec.)	1992	250
• AWALI-JAMHUR reconstruction of 66 kV Overhead Transmission Line	1994	120
• Supply of Steel Lattice Towers for SAIDA-ZAHRANI 66 kV OHTL	1995	100
• Supply of Steel Lattice Towers for SAIDA-MAHUK 66 kV OHTL	1996	100

MALTA

• Plant for manufacturing of electric motors with capacity over 4 kW and annual production of 50 000 ps	1982	4 000

NICARAGUA

• EL VIEHO 138/24.9 kV, 1x25 MVA Substation	1985	1 250
• PUNTE HUETE 138/24.9 kV, 1x15 MVA Substation	1985	950
• LAS BANDERAS 138/24.9 kV, 1x15 MVA Substation	1985	950
• MINA EL LIMON 69/24.9 kV, 1x15 MVA Substation	1985	800
• MATEARE 69/24.9 kV, 1x15 MVA Substation	1985	800
• Workshop for repairs of Distribution Transformers	1986	630

NIGERIA

• KANO STATE 33 kV, 354 km Overhead Transmission Line and 0.415 kV, 280 km Distribution Networks	1984	17 000
• KADUNA STATE 33 kV, 45 km Overhead Transmission Line and 0.415 kV, 20 km Distribution Networks	1984	4 000
• NEPA 33 kV, 2000 km Overhead Transmission Lines; 11 kV, 1200 km Overhead Transmission Lines and 0.415 kV, 1700 km Distribution Lines	1985	50 000
• CROSS RIVER STATE 11 kV, 300 km Overhead Transmission Lines and 0.415 kV, 650 km Distribution Networks	1986	24 000
• Ten complete training centers and laboratories for colleges	1986	10 000
• Complete electrification of Zones E and F-Abuja including 33 kV, 11 kV, 0.415 kV Cable Networks, Automatic Traffic Control System, Street Lighting and Emergency Call and Alarm System, ABUJA zone E 33/11 kV, 2x15 MVA, Substation ABUJA zone F 33/11 kV, 2x15 MVA Substation	1992	14 800

PAKISTAN

• Seven 66/11 kV, 5 MVA Substations for WAPDA	1970	2 100
• Three 66/11 kV, 7.5 MVA Substations for WAPDA	1972	1 200
• Six 66/11 kV, 10 MVA Substations for WAPDA	1973	3 000
• Vacuum Drying Installations for Power and Distribution Transformers	1973	800

RUSSIA

• Eighteen Complete Medical Centers	1987	5 400
• Twenty-five Complete Irrigation Pump Stations	1988	15 000

SYRIA

• HAMA 66/6.6 kV, 2x12.5 MVA Substation	1969	900
• HOMS 66/6.6 kV, 2x7.5 MVA Substation	1969	900
• Plant for manufacturing of Asynchronous Motors	1970	1 600

VIETNAM

• SHONG GOT 2 MW (2x1 MW) Hydro Power Plant	1968	1 000
• CHIENG NGAM 2 MW (2x1 MW) Hydro Power Plant	1968	1 000

Written by *Assoc. Prof.* Mire Spirov, *M.Sc. Electrical Engineer*

Science editor Alexander Vaklinov, *M.Sc. Electrical Engineer*
Copy editors Mariana Dotsinska and Zlatka Barakova
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